BRITISH MUSEUM (NATURAL HISTORY)

THE LONDON CLAY FLORA

BY

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AND

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WITH THIRTY-THREE PLATES AND SEVENTEEN FIGURES IN THE TEXT

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PREFACE

The fossil fruits and seeds of the London Clay found on the shore at Sheppey have attracted attention for more than two hundred years, and it is nearly a century since Bowerbank published the only important scientific treatise on them that has yet appeared. His work was never completed, and his vast collection of pyritized specimens was already diminished by decay when it was acquired by the British Museum in 1865. The still extensive relics of this collection, together with more recent acquisitions, have now been investigated by Mrs. Clement Reid and Miss M. E. J. Chandler, who have devoted seven years to the elucidation of the flora, and have themselves collected much new material. The present volume, embodying the results of their researches, is in effect the second part of the Catalogue of Cainozoic Plants in the Department of Geology, but since it could not be issued in the same form as the first part (on the Bembridge Flora), it appears as an independent volume. Partly owing to the size of the work, it has proved impossible to include a full account of the fossil woods of the London Clay. Descriptions of these, and of the additional material which is already accruing, may, it is hoped, be published later in a supplementary volume.

The importance of the authors' conclusions regarding the flora and climate of the London Clay, and the relations between fossil floras, will be evident from a study of the Introduction. The descriptive portion of the Catalogue, on which these conclusions are based, provides a further demonstration of the value of anatomical details in systematic work. The best thanks of the Department are due to Mrs. Reid and Miss Chandler for the skill and care with which they have carried out their investigations. In seeing the volume through the press, Mr. W. N. Edwards has been ably assisted by Mr. F. M. Wonnacott, who, in particular, has been responsible for the index.

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November, 1933.

AUTHORS' PREFACE

In acknowledging our indebtedness to all those whose help and co-operation has made it possible for us to carry out the investigation of the London Clay flora, we would first express our warmest thanks to the Keeper of the Geological Department of the British Museum for entrusting to us Bowerbank's great collection for study. And in the second place we would express our indebtedness to Mr. W. N. Edwards, Deputy-Keeper of the Department, who has throughout the research supplied us continually with information concerning not only Bowerbank's collection, but other collections of London Clay plants as well. He has also given us a large amount of information as to the work that has been done on the flora, and the literature connected with it; and has made many valuable criticisms of our text. The collection of new material at Sheppey, by the authors in the years 1928 and 1929, was made possible by a grant from the Royal Society to one of them.

It will readily be appreciated that the study of the flora has only been rendered possible by the generous help we have received from many quarters. For access to living material for comparison we would especially thank the Director and officers of Kew, who not only allowed us to borrow material for photography and microscopic examination, but by the gift of garden specimens and of surplus material from a large tropical collection, enabled us to make intimate studies of certain living fruits and seeds, which have furnished conclusive information not otherwise obtainable. We would also thank the Regius Keeper of the Royal Botanic Gardens, Edinburgh, for gifts of many garden specimens. To Dr. C. E. P. Brooks we are indebted for invaluable help in giving us an estimate of the probable mean temperature and climatic conditions of the London Clay period, as well as for other meteorological information, and for his very great kindness in reading through the original draft of the section on Climate in the Introduction, also for offering many valuable suggestions which we have incorporated in the text. To our many botanical friends we are indebted not only for continual interest in the study and much botanical information, but for useful suggestions on many points. To Mr. H. N. Ridley, F.R.S., formerly Director of the Botanic Gardens, Singapore, for placing his unrivalled knowledge of the Malayan forests and their flora at our disposal, and for referring us to Moseley's account in the "Challenger" Report of the drift from the Ambernoh River in New Guinea. To Mr. I. H. Burkill, late Director of the Botanic Gardens, Singapore, for frequent information as to the habitat of Malayan genera, for obtaining for us a magnificent collection of the fruits of *Nipa* from Mr. R. E. Holttum, the present Director of the Singapore Gardens, and for introducing us to Dr. A. Kerr's account of the drift on the Kaw Tao beach. To Mr. A. D. Cotton, Keeper of Kew Herbarium, not only for the loan of specimens and facilities for work in the Herbarium, but for obtaining the valuable information furnished by Mr. W. Nowell, Director of the East African Research Station at Amani, Tanga, Tanganyika Territory, as to the relation between temperatures in clearings and in the rain-forest itself. To Major R. W. G. Hingston for giving us temperature statistics regarding the canopy and floor of the rain-forests of British Guiana and for directing our attention to the patch of tropical forest above the Victoria Falls of the Zambesi. To the late Dr. T. F. Chipp, formerly Assistant Director of the Royal Gardens, Kew, we are indebted for allowing us to draw upon his great knowledge of tropical rain-forests in many parts of the world, especially in regard to the different temperatures and other conditions which prevail within the forests themselves and within clearings in the forests, and for information regarding the complex of conditions which determine the limits of rain-forest growth. To Dr. W. B. Turrill we are indebted for a discussion of the same subject, and for much valuable reference to literature. To Mr. C. Fischer for giving us information as to the conditions producing tropical rain-forest growth in the Nilgiri Hills; and to Mr. J. Hutchinson for similar information regarding the Drakensberg and other mountain ranges of South Africa. We are indebted to the late James Groves for information on the specimens of *Chara;* to Dr. R. Florin for notes on *Araucarites;* to Mr. T. H. Withers and Dr. F. W. Edwards for examining an insect pupa; and to Professor C. Houard, Professor J. W. Heslop Harrison, and Mr. A. W. Bartlett for a discussion of the galls.

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INTRODUCTION

I. DR. JAMES SCOTT BOWERBANK, F.R.S.

Before entering upon the subject of the London Clay fruits and seeds we must give an account of one with whose name their study must ever remain associated, and to whose zeal and energy we owe the great collection to be described in the following pages.

Dr. James Scott Bowerbank was born July 14, 1797, and died March 8, 1877. By birth a Londoner, he, like his father before him, was a City merchant and distiller, which business he actively pursued till 1847. It was during his hard-won leisure—" his business demanding constant and careful attention for at least twelve hours daily " (*Geol. Mag.*, 1877, p. 191)—that the work which made him famous was carried on. From his childhood he was devoted to the study of Natural History in various of its branches. In 1822, 1823, and 1824 he delivered courses of public lectures on Botany, and later, in 1831, on Human Osteology (1877, p. 192). About 1836 he formed with several of his geological friends, among whom were Searles V. Wood and N. T. Wetherell, " The London Clay Club," for the purpose of examining the fossils from that deposit and making a complete list of the species. In 1840 he published a separate work entitled " On the Fossil Fruits of the London Clay," the only scientific study that has hitherto been made of these interesting fossils, because the hasty work by Ettingshausen is not worthy to be regarded as such. In 1842 Bowerbank was elected a Fellow of the Royal Society. In 1847 he initiated the Palaeontographical Society, being supported by Buckland, de la Beche, and others. Besides his work on the London Clay he published other geological and zoological papers. In 1865 his collection of London Clay fruits and seeds was bought by the British Museum. It is stated on the prospectus printed on the back cover of the first volume of Bowerbank's work (the only one ever published) that during the period of his study " there have passed through his [the author's] hands more than 120,000 fruits and seeds, from which he has selected about 25,000 specimens." Unfortunately, with the passage of time a large proportion of these have decayed and perished, and it is only the remnant that remains to be described, although this in itself constitutes a very large collection.

For ourselves Bowerbank's work has stood for years as a model of what palaeobotanical study and exposition ought to be. And never more so than when, as in the past few years, we have had occasion to scrutinize it in its every detail. His observations, descriptions, and illustrations are so accurate that again and again we have been able to recognize and recover his type specimens when these had been mislaid among the thousands of specimens contained in the various jars in which the collection was preserved. That we have been able to do so is in large measure due to the beautiful copper-plate engravings by James de Carle Sowerby. Sowerby's figures of the fruits and seeds are all life-size, some of them not more than a quarter of an inch in their longest diameter. Yet they are so accurate in form and detail, that we have constantly been able to recognize the exact angle of vision and to trace every blotch and excrescence represented in the drawings. This outstanding accuracy of description and illustration has accordingly warranted us in accepting as correct, statements made by Bowerbank concerning specimens now decayed and vanished.

If Bowerbank failed, as fail, very largely, he did, to unravel the secrets of his wonderful collection, it was not from any slight or superficial work, but mainly because the knowledge of his time did not suffice to trace the relationship of the tropical forms there represented. For example, the genera known to botanists as *Platycarya* and *Toona* were described and named from the living forms, three years and six years, respectively, after Bowerbank had published his descriptions of the fossil fruits under the names *Petrophiloides Richardsonii* and *Cupressinites sulcatus*.

The problem of nomenclature thus raised is discussed on pp. 138, 279. Knowledge of tropical fruits and seeds is hard enough to come by even in these days of travel and botanical collection. One hundred years ago it must have been impossible of attainment on any scale adequate for the task before Bowerbank. But there was a second cause of failure. Sometimes he failed to recognize the intercalated films of structureless pyrites that fill the interspaces between successive seed- and fruit-coats, interpreting them as additional coats. And so confusion arose. This mistake is not surprising, as anyone who studies these fossils will soon learn. It is more to his credit that at times he did distinguish the films, than to his discredit that at times he missed them. Thus, if in the end we must sum up the results of Bowerbank's study as mostly failure in its ultimate object, it is a failure which by the manner of its execution has resulted in the production of one of the masterpieces of palaeobotanical literature. And it must not be forgotten that it was Bowerbank who identified the genus *Nipa*, the genus which seems to give the key to the interpretation of the history of the London Clay flora itself, and of the other hot Eocene floras of western Europe.

II. PREVIOUS WORK ON THE LONDON CLAY PLANTS

The fruits and seeds of the London Clay have attracted attention for more than two hundred years. The following is a list of works dealing with them in order of publication, or of writing, when not published, omitting brief references in text-books (Lyell, 1871 ; Mantell, 1894, which merely reproduce a few of Bowerbank's figures), and short papers, such as many of Gardner's, which make no new contributions ; but references to these will be found in the " List of works quoted " (p. 543).

1709. " Fossiliae Sheppeianae Catalogus," an anonymous work.

1757. Dr. J. Parsons figured forty-six varieties of fruits and other objects. The following determinations were suggested by him for some of these. We give our own names for some of the species in square brackets: Figs [bored wood], myrobalan, phaseolus, an American gourd, coffee-berries [seeds of one of the Anonaceae], two species of bean " very apparent " [endocarps of Icacinaceae], acorn [Lauraceae], fruit like small melon [*Oncoba*], Eastern mango [seed-cast of *Nipa*], *Euonymus* [*Cupanoides*], millipede or woodlouse [*Eohypserpa*], ear of corn or grass [*Araucarites*]. Parsons makes this remark, " Doubtless the smaller seeds, if carefully looked for, might be found fossil as well as these now produced, *viz.* such as have a firmness in the covering; but being small and mixed with dirt, sand, etc., probably is the reason of their being overlooked." With regard to this statement we may observe that we have not ourselves found any isolated seeds smaller than those of *Vitis* by direct search, although we have found many such enclosed within their fruits—*Protobarclaya*, *Trochodendron ?*, *Saxifragispermum*, *Toona*, two genera probably belonging to Celastraceae, *Cantitilia*, *Sphinxia* (Sterculiaceae), three species of Lythraceae, *Leucopogon*, *Oncoba*, etc. We had to give up the attempt to collect small seeds by sifting away the coarser material, because the masses of this coarse material proved prohibitive. The occurrence of the fruits led Parsons to speculate that the autumn was probably the time of year at which the Deluge occurred.

1777. E. Jacobs, in an appendix to his " Plantae Favershamiensis " (pp. 137, 138), noted some Sheppey fossil plants under the heads Lignum fossile, Equisetum, Fructus varii, and Aristae. He also recorded the rare occurrence of amber.

1781. William Jones (p. 381, pl. v) figured a few fossils from Sheppey. Among these we can recognize a piece of bored-wood with a thick bore-hole (fig. *a*), a fruit of *Oncoba* (fig. *c*)—Jones calls it " sandbox "—and a *Nipa* described as some species of cocoanut. On p. 447 is the remark, " we are not sure that any one of these is from the native fruits of this country or climate. Some of them were certainly produced in very distant parts of the globe."

1785. James Douglas illustrated a *Nipa* showing the kernel, which he described as a species of almond.

1801. Pennant (pp. 77–90, pl. opp. p. 88) figured a few plants from Sheppey. A *Nipa* (fig. 3), a *Faboidea* (figs. 10, 11), an *Oncoba* (fig. 16), and a *Cupanoides* (fig. 5) can be recognized.

1804. J. Parkinson (vol. i, pls. vi, vii) illustrated Sheppey fruits. Many of his figures are not recognizable, but we have identified some as follows: Pl. vi, fig. 1 wood, fig. 3 probably a concretion, fig. 4 possibly *Mastixia cantiensis* with the germination valve detached, fig. 9 *Jenkinsella apocynoides*, fig. 26 probably an endocarp of one of the Cornaceae, perhaps a *Mastixia*, figs. 27, 28 wood, fig. 29 a twig of *Araucarites;* Pl. vii, figs. 1, 2, 4, 5 are *Nipa* fruits, and fig. 3 a *Nipa* seed, figs. 4 and 5 representing the specimen previously figured by Douglas.

1809. James Sowerby illustrated amber (pp. 145–151, pls. 273, 274) and a few Sheppey fruits (p. 199, pl. 300). No attempt was made to identify them, save that one, obviously a fruit related to *Cupania*, was compared with *Thea viridis*, *Euphorbia*, and *Menispermum*. There are twelve in all arranged in three vertical and four horizontal rows. If for purposes of reference we number them thus, then we may give the following probable generic determinations. 1. *Stizocarya*, 2. *Hightea*, 3. *Cupanoides*, 4. *Hightea ?* 5. *Icacinicarya platycarpa*, 6. Not determined, 7. *Hightea* (exterior), 8. *Hightea* (placenta), 9. *Hightea* (with exterior broken so as to show placenta), 10. Lauraceae, 11. Icacinaceae ? 12. Bored wood ?

1.	2.	3.
4.	5.	6.
7.	8.	9.
10.	11.	12.

1810. The next notice of the fossils in order of time is the manuscript list by Francis Crow of Faversham, now in the possession of the British Museum (Natural History). The title of the work is " A Catalogue of Rare Fossil Fruits from Sheppey Island, etc., in the Collection of Francis Crow of Faversham, 1810, Being the Result of upwards of Twenty Years Collecting." Some of Crow's opening remarks are well worth quoting, for, so far as can be ascertained, he was the first to suggest the method of study which is the method we have continually used in our investigation of the London Clay fruits and seeds. He says, " I hope I may be acquitted of the charge of vanity in assigning credit for more experience in the investigation of Fossil Fruits than any Man and for an Invention my researches have led to which has facilitated the business of ascertaining the species more than any circumstance whatever. I mean that of opening them and displaying their internal structure. Notwithstanding which I have found great difficulty in ascertaining varieties from the Twelve following causes,

First, their being all of one colour.
Second, some appear to be fruits at an early time of vegetation.
Third, some appeared to be quite matured.
Fourth, some appear to be past maturity and have shed their seeds.
Fifth, some appear to have suffered by blight.

Sixth, the most considerable alteration from their primitive formation is perhaps from the very great Convulsion which deposited them in the bowels of the Earth.

Seventh, some of them appear to be seeds and other parts of Fruits similar to our Peach and Plumb stones, etc.

Eighth, some that were thought to be fruits have proved to be Excrescences of Insects after the manner of Oak-galls, etc.

Nine, some appear much like bulbous roots.

Ten, some that were thought to be Fruits have proved to be wood worn down by the action of the Sea by laying long on the shore similar to a smooth oblong pebble, but on opening them they show their parallel lines which at once proves them to be wood.

Eleven, some that were taken for fruits have by opening them, proved to be lumps of Pyrites which had the form of fruits.

Twelve, they are again subject to injury and alteration of figure by the rolling of the sea on the shore.

Thirteen, [added later] the want of more Botanical knowledge."

"The specimens here Delineated are selected from various productions of both animals and vegetables originally of a Country and Climate very different from our own, from the appearance of both animals and vegetables one would be inclined to think they once belonged to a Tropical, or high southern Latitude. Here they have laid undisturbed through a long succession of Ages that have revolved since the awful Catastrophe which deposited them there, until by the gradual encroachment of the Sea and the falling of the Cliff they are once more exposed to the light of the Sun."

On this follows the catalogue, the specimens being numbered 1–730 (not including several sheets of lettered drawings), and on the last page is a pencilled note as follows :

"There are in all 831 drawings and about 700 varieties, but the number of varieties could not be exactly given without further investigation with a considerable degree of Botanical knowledge.

"N.B. The person that figured them never was learnt to draw which is the occasion of many incorrection [*sic*] on that point."

Doubtless because "the person that figured them never was learnt to draw," it has been impossible to determine more than a few of the specimens figured by Crow, namely those having very distinctive features. We have arranged these below in botanical order, giving Crow's determinations in brackets, followed by the numbers of his drawings.

Araucarites sp. (ear of Corn) 63 (this is the same specimen as that figured by Parsons, 1757, pl. xvi, fig. 23), 434 ?

Cupressinites curtus Bowb. 292 ?

Nipa Burtini Brongn. (some labelled *Cocos*) 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 19 ?, 20 ?, 21 ?, 22, 30, 35, 61, 62, 64, and many lettered drawings.

Palmospermum excavatum n. sp. 642.

Tinospora excavata n. sp. 700.

Eohypserpa Parsonsi n. gen., n. sp., 658.

Bowerbankella tiliacoroidea n. gen., n. sp., 464.

Menispermaceae ("very rare, the only one I have ever found"), 656. We have never seen a specimen of this beautiful and distinctive species, which, judging by the drawing, might perhaps be related to *Tiliacora* Colebr.

Anonaspermum sp., 477, 570.

Protoravensara sheppeyensis n. gen., n. sp., 702 ?

Crowella globosa (Bowb.) n. gen., 218.

Lauraceae, fruit in cupule, 486.

Lauraceae, 46, 50, 454, 483, 544 ?, 686.

Wetherellia variabilis Bowb., 125, 146, 225, 321, 322, 490 ?, 493, 580.

Dracontomelon subglobosum n. sp., 625.

Lobaticarpum variabile n. gen., n. sp., 75 ?

Iodes corniculata n. sp., 695.

Palaeophytocrene foveolata n. gen., n. sp., 86, 518 ?
Stizocarya communis n. gen., n. sp., D Z E.
Cupanoides grandis Bowb., 74 ? [cf. Parsons, 1757, pl. xvi, fig. 5], 575.
Cantitilia polysperma n. gen., n. sp., 643, 553 ?, 716 ?.
Oncoba variabilis (Bowb.), 87 [cf. Parsons, 1757, pl. xv, fig. 16], 209 ?, 539, 600.
Minsterocarpum alatum n. gen., n. sp., B Z ?.
Hightea elliptica Bowb., 102 [placenta], 314 [placenta lying in fruit], 490 ?, 493, 580.
Nodules of bored-wood, 33, 34, 38, 67, 82, 88, 89, 115, 138.

Crow's collection was housed in the Philosophical and Literary Institution of Canterbury. A " Synopsis of the Museum " of this institution published in the year 1826, soon after its foundation, states that " Mr. Crow has been a most persevering collector of Fossils, etc., through the whole of his long life, and many rare specimens well attest his acumen as a collector." All but a very few of these fossils have now perished. The only specimen worth figuring and describing is the internal cast of a very large bivalvate fruit or pod with the valves appressed (Pl. XXX, figs. 22, 23), but a nut of *Nipa* is also preserved in the Museum. Among other fruits mentioned in the " Synopsis " are " the black walnut (*Juglans regia*)," a seed which " if not actually the coffee-berry . . . at least nearly approaches it," " fruits very like the olive from which oil is extracted," a seed " that bears a close affinity to an apple-pip," " the strobilus or cone of some tree of the fir or cypress family [which] looks as perfect in its detail as if fresh from the tree ; as are also the catkins of some amentaceous trees." It is impossible to do more than guess what species are indicated by these descriptions, with no specimens or illustrations to guide us. We have never seen any specimen bearing even a remote resemblance to *Juglans regia*. The coffee-berry may perhaps be the seed of one of the Anonaceae. The fruits like olives, perhaps those of *Mastixia*. And the strobils were probably those of *Petrophiloides*, one specimen of *P. Richardsonii* having been figured by Bowerbank from the Canterbury Museum (1840, pl. x, figs. 5–8).

1811. J. Parkinson (p. 339) referred to Sheppey fruits of which Francis Crow is said to have obtained some " seven hundred specimens, none of which are duplicate." [!]

1817. Sowerby (pp. 229–232, pl. 522) recorded resin from Highgate.

1822. Ad. Brongniart (pp. 314, 315 ; and pp. 327, 328) referred to Sheppey fruits and compared specimens figured by Parkinson with various palms.

1828. Brongniart described three species of fossil fruits from Sheppey under the following names : *Cocos Parkinsonis* [now known to be a *Nipa*] (p. 121) ; *Pandanocarpum oblongum* [also a *Nipa*] (pp. 135, 136, 138) ; *Amonocarpum* [sic] *depressum* (pp. 129, 130, 137). This fruit was recognized by Bowerbank from Brongniart's description as belonging to his genus *Cupanoides*.

1832. Lindley and Hutton (p. xliii), listed Brongniart's three species named above, together with additional genera from Sheppey based on portions of plants. These genera are *Palmacites*, *Flabellaria*, *Caulinites*, *Equisetum*, and *Fucoides*.

1840. In this year was published " A History of the Fossil Fruits and Seeds of the London Clay " by Bowerbank. It was to have been completed in five parts, of which only one was ever published. But the second part was announced, in a prospectus printed on the back cover of Part I, as in course of preparation, and to be published as early as possible with drawings and engravings by James de Carle Sowerby. In spite of this announcement we have entirely failed to trace any manuscript, notes, or illustrations for this volume ; or any printed copies.

There were two issues of Part I. Both are dated 1840, but certain facts show that the second issue must have been made as late as 1877, the year of Bowerbank's death, or soon after. The earlier issue has no title-page and no introduction, and the engravings are beautifully sharp and clear. The second issue has a title-page and, as an introduction, the reprint of a letter from Bowerbank containing instructions to the collectors of Sheppey fossils, which letter was first published in the *Magazine of Natural History*, 1840, n.s., iv (pp. 205, 206). The illustrations of the second issue are much less clear than those of the first. In the copy of this issue preserved in the Botanical Library of the British Museum (Natural History), there is a manuscript note by W. Carruthers stating that "The remainder of Bowerbank's Fossil Fruits [*i.e.* the copies of Part I] were bought at the sale of his effects by Reeves and Turner in 1877. They inserted this title-page and the letter from the *Mag. of Nat. Hist.* on the next two pages in the copies which they purchased." In sending us this information Mr. W. N. Edwards adds: "Copies of the book containing the introduction and title-page (dated 1840) were therefore presumably issued in 1877, or soon after."

It is generally recognized that the number of Bowerbank's species is often much greater than the distinctions between them warrant. Many are founded on slight individual differences which frequently are merely the effects of accident, such as abrasion or distortion. We give opposite a list of his families and genera, with such particulars as to the species as will enable students to compare them with our own determinations. The whole of his species are enumerated, although not all are named, so as to avoid waste of space.

1844. Bowerbank described and figured wood from the London Clay, which he referred to a species of *Piper*, but in 1872 Thiselton-Dyer showed that similar details of structure also occurred in other dicotyledons.

1849. Ad. Brongniart gave a brief summary of the genera described by Bowerbank. He accepted Bowerbank's reference both of the Sheppey fruits, and of fruits determined by himself (Brongniart) as *Pandanocarpum* and *Cocos*, to the genus *Nipa*. But he expressed the opinion that Bowerbank's species of *Nipadites* were based on individual variations in size, and not on specific differences. He also accepted Bowerbank's reference of *Amomocarpum* Brongn. to the Sapindaceae. Further, with regard to Bowerbank's species *Cupressinites* (*Solenostrobus* Endlicher) *subangulatus*, *C. corrugatus*, *C. sulcatus* and *C. semiplotus*, he states his opinion that they are not fruit of a conifer, but rather "un vrai fruit angiosperm à cinq valves," an opinion which the present work has amply confirmed. He also refused to accept *Hightea* as belonging to the Malvaceae.

1854. Prestwich published an important paper dealing with the thickness of the London Clay and the positions of the fossiliferous beds within it. He divided the deposit into four zones, the plant deposits being allocated as follows: Sheppey, Southend, and Brentwood in the first zone; Highgate Archway in the second; cliffs west of Herne Bay, Primrose Hill, Copenhagen Fields, Whetstone, and Kew in the third; Bognor, and the cliffs east of Herne Bay ? in the fourth.

In a footnote (p. 413) Prestwich states that in addition to the species listed on p. 9 Bowerbank had in his possession "seeds and fruits including Palmacean fruits, a few cones, fruits of Potentillas, and 1 Cocos, with seeds of 2 or 3 species of Anana" [*sic*].

1856. In a review of British Tertiary floras, La Harpe discussed the possibility of connecting the leaves found in other English Eocene deposits with the fruits found at Sheppey, but decided that neither the fruits nor the leaves were sufficiently well known, and that attempts to connect them could only be regarded as ill-founded. La Harpe also considered that Bowerbank had unduly multiplied the species of *Nipadites*, *Hightea*, and other genera.

1871. C. J. A. Meyer mentioned the occurrence of *Nipa* in sands with *Lingula*, in a temporary section exposed during dockyard extension works at Portsmouth. He also mentioned the occurrence of wood.

1874. T. Rupert Jones recorded two species of *Chara* from the London Clay of Copenhagen Fields, Islington.

1878. W. H. Shrubsole gave a brief account of the geology of Sheppey, published in a local guide to Sheerness.

1878–1879. During this winter Ettingshausen made a four months' visit to London, and as a result of this hurried study of Bowerbank's specimens, published a provisional list of Sheppey plants (1879, p. 388). This list met with an acceptance it in no way deserved, reference having been made to it again and again, and its determinations having been widely quoted. It was published without either descriptions or figures. Consequently, by the rules of nomenclature his determinations are *nomina nuda;* and we have treated them as such, because they have proved to be most erroneous. We make this statement because Bowerbank's collection was sent to us in the original jars in which it

Bowerbank.		Reid and Chandler.		Locality.
Family.	Genus and Species.	Family.	Genus and Species.	
Palmae ..	*Nipadites*, 13 spp.	Nipaceae ..	*Nipa Burtini*	Sheppey.
Malvaceae ? ..	*Hightea elliptica* (and 7 other spp.)	Myrtaceae ? ..	*Hightea oviformis*	,,
,, ?	,, *turgida*	,, ?	,, *turgida*	,,
Proteaceae ..	*Petrophiloides Richardsonii* (and 5 other spp.)	Juglandaceae	*Petrophiloides Richardsonii*	Swale Cliff, Herne Bay.
,,	,, *oviformis*	Lauraceae ..	*Beilschmiedia oviformis*	Minster.
Cupressineae	*Cupressinites curtus*, and *C. thujoides*	Cupressineae	*Cupressinites curtus*	Sheppey.
,,	,, *Comptonii*	,,	,, *curtus ?*	,,
,,	,, *globosus*, and *C. elongatus* }	Lauraceae ..	*Crowella globosa*	,,
,,	,, *recurvatus* }			
,,	,, *crassus*	Juglandaceae	*Juglandicarya crassa*	,,
,,	,, *sulcatus*, and *C. semiplotus*	Meliaceae	*Toona sulcata*	,,
,,	,, *subangulatus*	Myrtaceae ..	*Palaeorhodomyrtus subangulata*	,,
,,	,, *corrugatus*	Lythraceae ?	*Tamesicarpum polyspermum ?*	,,
,,	,, *subfusiformis*	Incerta sedis	*Carpolithus subfusiformis*	,,
,,	,, *tesselatus* (pl. x, figs. 26, 27)	,, ,,	,, *tessellatus*	,,
,,	,, ,, (pl. x, figs. 30, 31)	A concretion	of pyrites	,,
Sapindaceae ..	*Cupanoides tumidus*, and *C. inflatus*	Sapindaceae	*Cupanoides tumidus*	,,
,,	,, *grandis* (and 5 other spp.)	,,	,, *grandis*	,,
Unknown ..	*Tricarpellites communis* (and 3 other spp.)	Burseraceae ..	*Tricarpellites communis*	,,
,,	,, *curtus*	Incerta sedis	*Carpolithus curtus*	,,
,,	,, *gracilis*	,, ,,	,, *gracilis*	,,
,,	*Wetherellia variabilis*	Linaceae ..	*Wetherellia variabilis*	,,
Cucurbitaceae	*Cucumites variabilis*	Flacourtiaceae	*Oncoba variabilis*	,,
Unknown ..	*Faboidea crassicutis* (and 23 other spp.)	Icacinaceae ..	*Faboidea crassicutis*	,,
,,	,, *ventricosa*	,,	*Sphaeriodes ventricosa*	,,
Leguminosae	*Leguminosites longissimus*	Magnoliaceae	*Magnolia longissima*	,,
,,	,, *gracilis*	,,	,, ,, ?	,,
,,	,, *lobatus*, *L. dimidiatus* }			
,,	,, *inconstans*, *L. reniformis* }	,,	,, *lobata*	,,
,,	,, *aequilateralis* }			
,,	,, *subquadrangularis*	,,	,, *subquadrangularis*	,,
,,	,, *cordatus*	,,	,, *angusta ?*	,,
,,	,, *curtus*	,,	,, *subcircularis ?*	,,
,,	,, *enormis*	,,	,, *enormis*	,,
,,	,, *planus*, *L. trapeziformis*	,,	,, ,, ?	,,
,,	,, *lentiformis*	Incerta sedis	*Carpolithus lentiformis*	,,
,,	,, *elegans* (pl. **xvii**, fig. 6)	Icacinaceae ..	*Icacinicarya elegans*	,,
,,	,, ,, (pl. xvii, figs. 5, 7)	,, ?	*Carpolithus elegans*	,,
,,	,, *rotundatus*	,, ?	*Icacinicarya ? rotundata*	,,
,,	,, *subovatus*	Sapindaceae ?	*Sapindospermum ? subovatum*	,,
,,	,, *crassus*	Incerta sedis	*Carpolithus crassus*	,,
,,	*Mimosites Browniana*	Leguminosae	*Mimosites Browniana*	Assington.
Unknown ..	*Xulinosprionites latus*, and *X. zingiberiformis*	Probably bored wood.		Sheppey.

was preserved in the British Museum, and many of these jars still bore Ettingshausen's labels, so that we were able to trace the originals of many of his species. It was impossible to do this in all cases because, even if the specimens themselves had not decayed, the labels on many of the jars had done so; or in some cases the ink had faded, having been attacked by the decomposition products of the pyrites; again, in other cases the labels had become detached and were lying loose. But apart from such facts, we can state confidently that no one who had made more than the most superficial examination of the fossils themselves, or who had ever studied Bowerbank's work on them, could have conceived it possible to produce a list worthy of publication after only four months' study. Gardner (1886, p. 397) comments on this list as follows: "For reasons which will be apparent, I cannot help regretting that these lists are compiled and published; . . . in 1878, I was asked to assist in the preparation of a monograph on the Eocene flora in conjunction with Baron von Ettingshausen, who was to be responsible for the Palaeontological work, while I assisted in translating and otherwise.

"Our co-operation did not survive the first volume, for I speedily found that my views as to what were satisfactory data, not only on which to found new species but to identify old ones, were at variance with the Baron's."

When, therefore, Ettingshausen made the following statement in connexion with his list: "I feel now sure that we possess in the fruits and seeds of Sheppey, the key to the more precise determination of many of the genera and species of fossil plants which in other localities are known only by their leaves," he had almost no grounds for making it. Even had his determinations of the London Clay species been well founded, it would be both unwise and undesirable to connect, as belonging to the same species, fruits from one locality with leaves from another. They might be related, but the proof that they were would be wanting. The inadvisability of such a course becomes the more apparent when it is remembered how many species of a single genus often grow side by side; and how many may occur in the same deposit.

In compiling and commenting on the list of Ettingshausen's species we have had to introduce three columns: the first to give his own published list; the second the names on the jars, in his own handwriting, which seem to refer to those of his list; the third our own determination of the specimens concerned. This threefold arrangement is necessary because, as a consequence of the destruction of labels already referred to, and the decay of some of the specimens, it has not been possible always to trace the originals of Ettingshausen's names. And the matter is further complicated by the fact that the specific names in his published list do not always agree with those in his own handwriting on the jars. Thus the only *Symplocos* listed by him is *S. radobojana*, whilst the only *Symplocos* named on the jars is *S. sagoriana*. Presumably, therefore, the two names connote the same species, Ettingshausen having changed his mind as to the most suitable appellation. Again, where he has listed Bowerbank's species, and there are no specimens bearing his own labels, we have assumed that he has usually adopted Bowerbank's sorting and naming of species without alteration. But in a few cases we have found jars labelled with Bowerbank's names, in Ettingshausen's handwriting, which contain specimens that do not agree with Bowerbank's types as figured and described. Evidently there has been some blunder. Thus a specimen labelled *Hightea turbinata* Bowerbank, is not a *Hightea* at all, but belongs to an entirely different family, and to a genus which we have described as *Protocommiphora*.

In the following list † indicates that the specific name on a jar does not agree with that in the published list.

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Sphaeria Flabellariae Ett. & Gard.	*Sphaeria Flabellariae.*	*Sabal* sp. leaf, with small circular patches of pyrites.
Callitris curta Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Cupressinites curtus* Bowerb.
Callitris comptoni Bowerb. sp.	,, ,, ,,	*Cupressinites curtus* Bowerb.
Solenostrobus subangulatus Bowerb. sp.	,, ,, ,,	*Palaeorhodomyrtus subangulata* (Bowerb.).
Solenostrobus corrugatus Bowerb. sp.	*Cupressinites corrugatus.* [Label only, specimen decayed.]	? *Tamesicarpum polyspermum* n. gen. & sp.
Solenostrobus sulcatus Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Toona sulcata* (Bowerb.).
Solenostrobus semiplotus Bowerb. sp.	*Cupressinites semiplotus.* [The specimen does not agree with *Cupressinites semiplotus* of Bowerbank.]	*Cantitilia polysperma* n. gen. & sp.
Hybothya crassa Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Juglandicarya crassa* (Bowerb.).
Cupressinites globosus Bowerb. sp.	,, ,, ,,	*Crowella globosa* (Bowerb.).
Cupressinites elongatus Bowerb. sp.	,, ,, ,,	*Crowella globosa* (Bowerb.).
Cupressinites recurvatus Bowerb. sp.	,, ,, ,,	*Crowella globosa* (Bowerb.).
Cupressinites subfusiformis Bowerb. sp.	,, ,, ,,	*Carpolithus subfusiformis* (Bowerb.).
Sequoia Bowerbankii Ett. & Gard. (syn. with *Petrophiloides Richardsoni, P. cylindricus, P. cellularis,* and *P. ellipticus* Bowerb.).	*Sequoia Bowerbankii* Ett.	*Petrophiloides Richardsonii* (Bowerb.).
Pinus Sheppyensis Ett. & Gard.	? . . . *Sheppyensis* Ett. & Gard. [Label torn.]	Wood simulating cones, apparently nodes with short internodes and scars of branches.
Salisburia eocenica Ett. & Gard.	*Ginkgo ? eocenica* Ett. & Gard.	Icacinaceae. Genus ?
Cyperites eocenicus Ett. & Gard.	†*Cyperites* sp.	*Mastixia parva* n. sp. *Carpolithus* sp. 46 (internal cast). Indeterminable internal cast of a much abraded carpel.
Agave eocenica Ett. & Gard.	[Completely decayed.]	
Smilax pristina Ett. & Gard.	†*Smilax* sp. n. 2.	Indeterminable abraded locule-cast.
Caulinites Sheppyensis Ett. & Gard.	[Completely decayed.]	
Musa eocenica Ett. & Gard.	*Musa* . . . [Label torn.]	*Juglandicarya depressa* n. gen. & sp.
Amomum Sheppyense Ett. & Gard.	†*Amomum* sp. no. 1.	Fragments of wood.
Amomum stenocarpum Ett. & Gard.	†*Amomum* sp. no. 2.	Fragments of wood.
	†*Amomum* sp.	Gall ? Spindle-shaped formed of angular coarse cells, type figured Pl. XXXIII, figs. 26–28. Immature *Nipa Burtini* (Brongn.).
Nipa Burtini Brongn. sp.	[No specimen labelled by Ettingshausen.]	*Nipa Burtini* (Brongn.).
Nipa elliptica Bowerb. sp.	,, ,, ,,	
Nipa lanceolata Bowerb. sp.	,, ,, ,,	
Nipa Parkinsonis Brongn. sp.	,, ,, ,,	
Nipa semiteres Bowerb. sp.	,, ,, ,,	
Oenocarpus Sheppyensis Ett. & Gard.	[Completely decayed.]	
Areca prisca Ett. & Gard.	,, ,,	
Areca recentior Ett. & Gard.	*Areca recentior.*	Indeterminable decayed seed or locule-cast.
Iriartea striata Ett. & Gard. *Iriartea punctata* Ett. & Gard.	†*Iriartea eocenica.*	Internal cast of seed, indeterminable, may show evidence of 2 cotyledons. *Carpolithus* sp. 38.

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Livistona eocenica Ett. & Gard.	*? . . . tona eocenica.* [Label torn.]	*Hightea elliptica* Bowerb.
	Livistona eocenica.	Cornaceae § Mastixioideae. Genus ?
Sabal major Ung.	*Sabal major* Ung. [leaf].	*Sabal* sp.
	Sabal major Ung. [decayed seeds].	Indeterminable.
	Sabal major Ung. [seeds].	Lauraceae indeterminable.
Sabal Dryadum Ett. & Gard. *Sabal Oreadum* Ett. & Gard. *Sabal Dianae* Ett. & Gard.	†*Sabal punctata.*	*Cinnamomum globulare* n. sp. Lauraceae indeterminable.
	†*Sabal* sp.	*Erythropalum ? striatum.* *Ardisia ? eocenica* n. sp. *Tinospora excavata* n. sp. *Palaeallophylus ovoideus* n. gen. & sp., entered in Museum register as *Laurus eocenica.*
Chamaerops borealis Ett. & Gard.	*Chamaerops borealis.*	*Lagenoidea trilocularis* n. gen. & sp.
Trinax Bowerbankii Ett. & Gard. var. α. *globosa.* *Trinax Bowerbankii* Ett. & Gard. var. β. *elliptica.*	*Trinax Bowerbankii.*	*Erythropalum europaeum* n. sp. *Erythropalum* (?) *striatum* n. sp. *Laurocarpum sheppeyense* n. gen. & sp.
Bactris prisca Ett. & Gard.	*Bactris prisca.*	*Laurocarpum paradoxum* n. sp.
Asterocaryum Europaeum Ett. & Gard.	*Asterocaryum Europaeum.*	*Beilschmiedia gigantea* n. sp. ? Probably *Beilschmiedia pyriformis* n. sp. [specimen decayed]. *Laurocarpum paradoxum* n. gen. & sp. Bored wood with narrow cylindrical cavity, as in Pl. XXXIII, figs. 6, 7, 8. Bored wood with spindle-shaped cavity and coarse radiating fibrous structure, as in Pl. XXXIII, fig. 4. Concretion simulating a palm seed with large embryo-scar and tri-radiate fissure. Cf. Pl. XXXIII, figs. 36, 37. Bored wood or gall with cavity occupied by insect pupa. Cf. Pl. XXXIII, figs. 23–25.
Elaeis eocenica Ett. & Gard.	*Elaeis eocenica.*	*Tinomiscoidea scaphiformis* n. gen. & sp. *Litsea pyriformis* n. sp. Lauraceae indeterminable. *Wetherellia variabilis* Bowerb. *Faboidea crassicutis* Bowerb. Woody nodule, *Xulinosprionites* type. Bored wood or gall. Casts of three fruits, all different and all indeterminable.
Aronium eocenicum Ett. & Gard.	†*Aronium* sp. n.	Specimen decayed and indeterminable.
Quercus Lonchitis Ung. *Quercus drymeja* Ung. *Quercus eocenica* Ett. & Gard.	[No specimens, one detached label, †*Quercus* sp.]	

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Corylus primigenia Ett. & Gard.	Jar labelled 53513, name illegible.	*Laurocarpum ovoideum* n. sp. (53513 entered in Museum register as *Corylus eocenica.*)
Juglans eocenica Ett. & Gard.	*Juglans eocenica.*	*Sphaeriodes ventricosa* (Bowerb.). *Tamesicarpum polyspermum* n. gen. & sp. *Beilschmiedia ?* (or *Endiandra ?*) *crassicuta* n. sp.
Euphorbiophyllum eocenicum Ett. & Gard.	*Euphorbiophyllum* . . . [Label torn.]	*Lagenoidea trilocularis* n. gen. & sp.
Liquidambar eocenicum Ett. & Gard.	*Liquidambar eocenicum.*	Bored wood with spindle-shaped cavity and coarse radiating structure; of the type figured, Pl. XXXIII, fig. 4.
Petrophiloides imbricatus Bowerb.	*Petrophiloides imbricatus* Bowerb.	Woody fragment. *Petrophiloides Richardsonii* Bowerb.
Petrophiloides conoideus Bowerb.	[No specimen labelled by Ettingshausen.]	*Petrophiloides Richardsonii* Bowerb.
Petrophiloides oviformis Bowerb.	*Petrophiloides oviformis* Bowerb. [Label only.]	*Beilschmiedia oviformis* (Bowerb.).
Proteoides bisulcatus Ett. & Gard.	[No specimen or label.]	——
Laurus Lalages Ung.	[No specimen or label.]	? *Palaeallophylus ovoideus,* 53523 (53523 is entered in Museum register as *Laurus eocenica,* although jar is labelled *Sabal* sp.).
Nyssa eocenica Ett. & Gard.	*Nyssa eocenica.* [Label only seen, specimen decayed.]	——
Cinchonidium priscum Ett. & Gard.	[No specimen or label.]	——
Strychnos Urani Ett. & Gard.	†*Strychnos* sp. n.	Lauraceae, indeterminable.
Apocynophyllum Sheppyense Ett. & Gard.	*Apocynophyllum Sheppyense.*	*Ochrosoidea sheppeyensis* n. gen. & sp.
Solanites elegans Ett. & Gard.	*Solanites elegans.*	*Stizocarya communis* n. gen. & sp.
Sapotacites Mimusops Ett. & Gard.	†*Sapotacites* sp. 1.	*Magnolia crassa* n. sp.
Sapotacites chrysophylloides Ett. & Gard.	†*Sapotacites* sp. 2.	*Iodes multireticulata* n. sp. *Iodes multireticulata* n. sp. ?
Diospyros eocenica Ett. & Gard.	*Diospyros eocenica.*	*Sabal grandisperma* n. sp. *Serenoa eocenica* n. sp. *Palmospermum ?* sp. 7 ? *Cinnamomum globulare* n. sp. *Laurocarpum paradoxum* n. gen. & sp. *Laurocarpum* sp. 16. Lauraceae, indeterminable. Rolled wood.
Diospyros Pleadum Ett. & Gard.	[No specimen or label.]	——
Symplocos radobojana Ung.	*Symplocos sagoriana.*	*Protonyssa bilocularis* n. gen. & sp.
Menispermacites abutoides Ett.	*Menispermacites abutoides.*	*Bowerbankella tiliacoroidea* n. gen. & sp. *Tinomiscoidea scaphiformis* n. gen. & sp.
Magnolia eocenica Ett. & Gard.	*Magnolia eocenica.*	*Magnolia* sp. Decayed prior to study, hence not specifically determinable.
Illicium Apollinis Ett. & Gard.	†*Illicium* sp. [Label only, specimen decayed].	——

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Thlaspidium ovatum Ett. & Gard.	[No specimen or label.]	——
Nelumbium Buchii Ett.	*Nelumbium Buchii* Ett.	*Erythropalum europaeum* n. sp. Icacinaceae ? indeterminable. Lauraceae, indeterminable. 1 lead bullet, etc.
Nelumbium microcarpum Ett. & Gard.	*Nelumbium microcarpum.*	*Palaeophytocrene foveolata* n. gen. & sp.
Victoria Sheppyensis Ett. & Gard.	*Victoria Sheppyensis.*	*Palaeallophylus ovoideus* n. gen. & sp. *Laurocarpum sheppeyense* n. sp.
Victoria Najadum Ett. & Gard.	†*Victoria* sp. 2. [Detached label only.]	——
Cucumites Sheppyensis Ett. & Gard.	[No specimen or label.]	——
Theobroma Nimrodis Ett. & Gard.	†*Theobroma* sp.	*Faboidea crassicutis* Bowerb.
Theobroma Zoroastri Ett. & Gard.	†*Theobroma* sp. 2.	*Laurocarpum* sp. 12.
Hightea elliptica Bowerb. (syn. *Hightea attenuata* Bowerb., *H. fusiformis* Bowerb.).	*Hightea attenuata* Bowerb. (syn. *H. elliptica* Bow.: Ett.)	*Neuroraphe obovatum* n. gen. & sp.
Hightea elegans Bowerb.	[No specimen labelled by Ettingshausen.]	*Hightea elliptica* Bowerb.
Hightea inflata Bowerb.	,, ,, ,,	,, ,,
Hightea oviformis Bowerb.	,, ,, ,,	,, ,,
Hightea turbinata Bowerb.	*Hightea turbinata* Bowerb.	*Protocommiphora europaea* n. gen. & sp.
Hightea orbicularis Bowerb.	[No specimen labelled by Ettingshausen.]	——
Hightea minima Bowerb.	*Hightea minima* [label only].	——
Hightea turgida Bowerb.	*Hightea turgida.*	*Hightea turgida* Bowerb.
No equivalent name in list.	*Hightea magn* . . . Bow. [Label torn. No such species described by Bowerbank.]	*Hightea elliptica* Bowerb.
No equivalent name in list	*Hightea* sp.	*Hightea elliptica* Bowerb. *Mastixia cantiensis* n. sp. *Langtonia bisulcata* n. gen. & sp. *Lanfrancia subglobosa* n. gen. & sp.
No equivalent name in list.	*Hightea* Bowerbank.	*Dracontomelon subglobosum* n. sp.
Apeibopsis variabilis Bowerb. sp. (syn. *Cucumites v.* Bowerb.).	*Apeibopsis variabilis.*	*Oncoba variabilis* n. sp. *Magnolia angusta* n. sp. *Caxtonia rutacaeformis* n. gen. & sp. *Clausenispermum dubium* n. gen. & sp. *Sapoticarpum rotundatum* n. gen. & sp. *Lagenoidea trilocularis* n. gen. & sp. Much abraded indeterminable bodies.
	Cucumites variabilis.	*Oncoba variabilis.* *Wetherellia variabilis.*
Corchorites quadricostatus Ett. & Gard.	†*Corchorites* sp. 1.	*Minsterocarpum alatum* n. gen. & sp.
Corchorites quinquecostatus Ett. & Gard.	[No specimen or label.]	——
Acer sp. *adhuc indeterminata.*	[No specimen or label.]	——
Sapindus eocenicus Ett. & Gard.	†*Sapindus Sheppyensis.*	Small worn pyrites seed-cast, indeterminable. Probably not *Sapindus.*
Cupania lobata Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Cupanoides grandis* Bowerb.
Cupania subangulata Bowerb. sp.	,, ,, ,,	,, ,,

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Cupania tumida Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Cupanoides tumidus* Bowerb.
Cupania depressa Bowerb. sp.	,, ,, ,,	*Cupanoides grandis* Bowerb.
Cupania corrugata Bowerb. sp.	,, ,, ,,	,, ,,
Cupania grandis Bowerb.	,, ,, ,,	,, ,,
Cupania inflata Bowerb. sp.	,, ,, ,,	*Cupanoides tumidus* Bowerb.
Cupania pygmaea Bowerb. sp.	,, ,, ,,	*Cupanoides grandis* Bowerb.
Eugenia eocenica Ett. & Gard.	*Eugenia eocenica.* [No specimen, label only.]	——
Eucalyptus oceanica Ung.	[No specimen or label.]	——
Metrosideros microcarpa Ett. & Gard.	,, ,,	——
Lawsonia Europaea Ett. & Gard.	,, ,,	——
Cotoneaster Sheppyensis Ett. & Gard.	*Cotoneaster Sheppyensis.*	*Neuroraphe obovatum* n. gen. & sp. Lauraceae, indeterminable.
Prunus prisca Ett. & Gard. *Prunus Druidum* Ett. & Gard.	†*Prunus eocenica.*	Decayed prior to study. Probably Icacinaceae.
Amygdalus eocenica Ett. & Gard.	*Amygdalus eocenica.*	*Iodes eocenica* n. sp. *Sphaeriodes ventricosa* n. sp.
Amygdalus Sporadum Ett. & Gard.	†*Amygdalus* sp. n. 2.	Icacinaceae. *Incertae sedis.*
Podogonium Sheppyense Ett. & Gard.	*Podogonium Sheppyense.*	*Sapotispermum sheppeyense* n. gen. & sp.
Bauhinia primigenia Ett. & Gard.	*Bauhinia primigenia.*	*Sapotispermum sheppeyense.* *Faboidea crassicutis* Bowerb. *Carpolithus nervosus* n. sp.
Faboidea longiuscula Bowerb. sp.	[No specimen labelled by Ettingshausen.]	*Faboidea crassicutis* Bowerb.
Faboidea crassa Bowerb.	,, ,, ,,	,, ,,
Faboidea crassicutis Bowerb.	,, ,, ,,	,, ,,
Faboidea planodorsa Bowerb.	,, ,, ,,	,, ,,
Faboidea symmetrica Bowerb.	*Faboidea symmetrica* Bow.	*Icacinicarya platycarpa* n. gen. & sp.
Faboidea plana Bowerb.	[No specimen labelled by Ettingshausen.]	*Faboidea crassicutis* Bowerb.
Faboidea marginata Bowerb.	,, ,, ,,	,, ,,
Faboidea semicurvilinearis Bowerb.	,, ,, ,,	,, ,,
Faboidea larga Bowerb.	,, ,, ,,	,, ,,
Faboidea complanata Bowerb.	,, ,, ,,	,, ,,
Faboidea subdisca Bowerb.	,, ,, ,,	,, ,,
Faboidea oblonga Bowerb.	,, ,, ,,	,, ,,
Faboidea ovata Bowerb.	,, ,, ,,	,, ,,
Faboidea ventricosa Bowerb.	,, ,, ,,	*Sphaeriodes ventricosa* (Bowerb.).
Faboidea robusta Bowerb.	,, ,, ,,	*Faboidea crassicutis* Bowerb.
Faboidea pinguis Bowerb.	,, ,, ,,	,, ,,
Faboidea subrobusta Bowerb.	,, ,, ,,	,, ,,
Faboidea planimeta Bowerb.	,, ,, ,,	,, ,,
Faboidea quadrapes Bowerb.	,, ,, ,,	,, ,,
Faboidea bifalcis Bowerb.	,, ,, ,,	,, ,,
Faboidea tenuis Bowerb.	,, ,, ,,	,, ,,
Faboidea subtenuis Bowerb.	,, ,, ,,	,, ,,
Faboidea rostrata Bowerb.	,, ,, ,,	,, ,,
Faboidea doliformis Bowerb.	,, ,, ,,	,, ,,
Faboidea acuta Bowerb.	,, ,, ,,	,, ,,
Faboidea angustissima Ett. & Gard.	*Faboidea angustissima.* [Label only.]	——
No equivalent name in list.	*Faboidea elliptica* Bowerb. [No such species described by Bowerbank.]	*Protocommiphora europaea* n. gen. & sp.

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
No equivalent name in list.	*Faboidea* Bowerb.	*Iodes multireticulata* n. sp. *Faboidea crassicutis* Bowerb. *Wetherellia variabilis* Bowerb. *Canticarya ventricosa* n. gen. & sp. *Canticarya sheppeyensis* n. gen. & sp. *Canticarya ovalis* n. gen. & sp. *Euphorbiospermum crassitestum* n. gen. & sp. *Euphorbiotheca sheppeyensis* n. gen. & sp. Indeterminable internal casts.
Leguminosites subovatus Bowerb.	[No specimen labelled by Ettingshausen.]	——
Leguminosites crassus Bowerb.	*Leguminosites crassus* Bowerb.	*Icacinicarya ovoidea* n. gen. & sp. *Iodes multireticulata ?* [The specimens do not agree with *Leguminosites crassus* of Bowerbank.]
Leguminosites elegans Bowerb.	[No specimen labelled by Ettingshausen.]	*Icacinicarya elegans* (Bowerb.).
Leguminosites rotundatus Bowerb.	*Leguminosites rotundatus* Bowerb. [Specimen decayed.]	*Icacinicarya rotundata* (Bowerb.).
Leguminosites longissimus Bowerb.	[No specimen labelled by Ettingshausen.]	*Magnolia longissima* (Bowerb.).
Leguminosites gracilis Bowerb.	,, ,, ,,	*Magnolia longissima* (Bowerb.) ?
Leguminosites enormis Bowerb.	,, ,, ,,	*Magnolia enormis* (Bowerb.).
Leguminosites dimidiatus Bowerb.	,, ,, ,,	*Magnolia lobata* (Bowerb.).
Leguminosites lentiformis Bowerb.	*Leguminosites lentiformis* Bowerb. [Label only, no specimen.]	——
Leguminosites planus Bowerb.	[No specimen labelled by Ettingshausen.]	*Magnolia enormis* (Bowerb.) ?
Leguminosites lobatus Bowerb.	,, ,, ,,	*Magnolia lobata* (Bowerb.).
Leguminosites inconstans Bowerb.	,, ,, ,,	,, ,,
Leguminosites reniformis Bowerb.	,, ,, ,,	,, ,,
Leguminosites curtus Bowerb.	,, ,, ,,	*Magnolia subcircularis* n. sp. ?
Leguminosites subquadrangularis Bowerb.	,, ,, ,,	*Magnolia subquadrangularis* (Bowerb.).
Leguminosites aequilateralis Bowerb.	,, ,, ,,	*Magnolia lobata* (Bowerb.).
Leguminosites trapeziformis Bowerb.	,, ,, ,,	*Magnolia enormis* (Bowerb.) ?
Leguminosites cordatus Bowerb.	*Leguminosites cordatus* Bowerb. [Label only, no specimen.]	*Magnolia angusta* n. sp. ?
No equivalent name in list.	*Leguminosites* Bowerb.	*Magnolia angusta* n. sp. *Magnolia lobata* n. sp. *Magnolia subquadrangularis* (Bowerb.).
	Leguminosites Bowerbankii.	Decayed fragmentary indeterminable fruits. Icacinaceae, indeterminable.
Xulinosprionites latus Bowerb.	[No specimen labelled by Ettingshausen.]	Bored wood or gall.
Xulinosprionites zingiberiformis Bowerb.	,, ,, ,,	,, ,,
Mimosites Brownianus Bowerb.	*Mimosites Brownianus* Bowerb.	*Mimosites Brownianus* Bowerb.
Wetherellia variabilis Bowerb.	*Wetherellia variabilis* Bowerb.	*Wetherellia variabilis* Bowerb. *Cantitilia polysperma* n. gen. & sp. *Lagenoidea trilocularis* n. gen. & sp.
Tricarpellites communis Bowerb.	*Tricarpellites* Bowerb.	*Tricarpellites communis* Bowerb. [Entered in Museum register as *Tricarpellites Bowerbankii.*]

Ettingshausen's published list, 1879.	Corresponding labels on jars in Ettingshausen's handwriting.	Our determinations.
Tricarpellites patens Bowerb.	[No specimen labelled by Ettingshausen.]	*Tricarpellites communis* Bowerb.
Tricarpellites curtus Bowerb.	,, ,, ,,	*Carpolithus curtus* (Bowerb.).
Tricarpellites crassus Bowerb.	*Tricarpellites crassus* Bowerb.	Taxaceae. Genus ? [Specimen does not agree with *Tricarpellites crassus* of Bowerbank.]
Tricarpellites gracilis Bowerb.	[No specimen labelled by Ettingshausen.]	*Carpolithus gracilis* (Bowerb.).
Tricarpellites aciculatus Bowerb.	,, ,, ,,	*Tricarpellites communis* Bowerb.
Tricarpellites rugosus Bowerb.	,, ,, ,,	*Tricarpellites communis* Bowerb.
Carpolithes, 37 different named species.	[We have listed only those species which have their labels preserved. All were merely numbered without specific names.]	
	Carpolithes sp. 2.	*Cantitilia polysperma* n. gen. & sp.
	Carpolithes sp. 4 ?	*Icacinicarya minima* n. gen. & sp.
	Carpolithes sp. 5.	*Icacinicarya platycarpa* n. gen. & sp. *Carpolithus* sp. 47.
	Carpolithes sp. 8.	*Sphaeriodes ventricosa* n. gen. & sp.
	Carpolithes sp. 10.	*Cinnamomum globulare* n. sp.
	Carpolithes sp. 21.	Lauraceae, indeterminable.
	Carpolithes sp. 24.	*Iodes multireticulata* n. sp. (lobed specimen).
	Carpolithes sp. 27.	*Dunstania Ettingshauseni* (Gard.) n. gen.
	Carpolithes sp. 33.	Large seed or locule-cast, indeterminable.
	Carpolithes sp. [number undecipherable].	*Iodes corniculata* n. sp. *Iodes multireticulata* n. sp.
	Carpolithes sp. [number undecipherable].	*Protocommiphora europaea* n. gen. & sp.
? *Cucumites Sheppyensis* or *Caulinites Sheppyensis*.	. . . *ites Sheppyensis* sp. n. [Name mutilated.]	*Sapoticarpum dubium* n. gen. & sp.

1879. Gardner and Ettingshausen made the next contribution to the study of the London Clay plants. In the " British Eocene Flora " (p. 11) they gave a few introductory remarks on the flora and a summary of earlier literature.

1883–1886. Gardner described and figured the species listed on page 18.

Discussion of Gardner's determinations will be found under the different genera to which we have either referred the species, or suggested a possible reference; when it has been impossible to trace a generic relationship, the discussion will be under the family. It is unfortunate that with the possible exception of *Pinus* none of his determinations will stand scrutiny. Consequently, in reality, Gardner made very little addition to the true knowledge of the flora by his contributions to the " British Eocene Flora," for the work was never carried beyond the Gymnosperms.

1881. W. H. Shrubsole and F. Kitton described the diatoms of the London Clay and noted their distribution.

1884. Gardner published a short paper on the much discussed cones named by Bowerbank *Petrophiloides*. In this paper, which was well illustrated, he gave a good and detailed description of the strobils. His determination of the species as *Alnus* was wrong, as even his own description shows; nevertheless, he made a very valuable contribution to our knowledge of the species by pointing out that the apparent scales were merely the lozenge-shaped infillings of pyrites between the true scales. The application of this observation to other London Clay species has greatly assisted us in the whole study of the flora.

1886*a*. Gardner, in an account of the occurrence of teredo-bored wood, quotes W. H. Shrubsole's statement that all logs except small twigs found *in situ* at Sheppey, whether in the cliffs or on the foreshore, were teredo-bored, and were bored on the lower side only, showing that they had been attacked when floating on the surface, and had then quickly become water-logged and sunk.

1886. Gardner recorded, but without figures or description, his discovery of "the very unmistakable seed of *Verschaffeltia*, a genus of Palms from Seychelles, quite new to fossil floras" (p. 402). We have not seen this specimen and can make no comment except to say that the present-day distribution is not inconsistent with that of the allies of the London Clay plants.

1887. Gardner made a brief reference to the London Clay flora, noting its supposed richness in palms (*Verschaffeltia, Sabal, Desmoncus, Areca, Monodora*, etc.). He added (p. 248), "the difficulties we fear of determining anything but a fraction of the Sheppey fruits must prove insurmountable. Their outer coats are for the most part destroyed, and some part of their inner structure, nearly always quite different in form from that which is external, is revealed. Botanists have been able to determine but few of the drifted fruits brought home by the *Challenger*, though these are more perfect and of living species belonging to definite and known forms."

1894. Dr. A. B. Rendle monographed the Nipaceae from Sheppey, but he was not concerned with other members of the flora.

1902. C. Reid (p. 18) published a record of a leaf from the London Clay of Verwood, Dorset, which he referred to *Hakea*.

1919. Professor A. C. Seward reviewed those of the Sheppey fruits and woods referred to Coniferae, and published an account of a new species *Cupressinoxylon Holdenae*.

1928. A. G. Davis gave an account of sections in the London Basin exposed during the railway extension between Clapham and Morden. He recorded *Nipa, Hightea*, diatoms, and wood.

Gardner.			Reid and Chandler.		
Family.	Genera and Species.	References to "Eocene Flora."	Family.	Genera and Species.	Comments.
Cupressineae	*Callitris curta* Bowerb.	1883, p. 21, pl. ix, figs. 7, 8.	Cornaceae ..	*Dunstania Ettingshauseni*	——
,,	*Callitris curta* Bowerb.	1883, p. 21, pl. ix, figs. 9–11.	Cupressineae	*Cupressinites curtus*	Type of *Cupressinites curtus* Bowerb.
,,	*Callitris curta* Bowerb.	1883, p. 21, pl. ix, fig. 12.	Juglandaceae	*Juglandicarya crassa*	Type of *Cupressinites crassus* Bowerb.
,,	*Callitris curta* Bowerb.	1883, p. 21, pl. ix, figs. 13–21.	Myrtaceae ..	*Palaeorhodomyrtus subangulata*	Figs. 15–17, types of *Cupressinites subangulatus* Bowerb.
,,	*Callitris Ettingshauseni* Gard.	1883, p. 22, pl. ix, figs. 1–6.	Cornaceae ..	*Dunstania Ettingshauseni*	——
Taxaceae ..	*Ginkgo ? eocenica* Ett.	1883, p. 46, pl. ix, figs. 31–34.	Icacinaceae ..	Genus ?	——
Podocarpeae	*Podocarpus argillaelondinensis* Gard.	1883, p. 52, pl. ix, figs. 35, 36.	Lauraceae ?	Genus ?	Perhaps a wrinkled berry.
Taxodieae ..	*Athrotaxis ? subulata* Gard.	1884, p. 43, pl. xi, figs. 2–14.	Araucarineae	*Araucarites* sp. ?	——
Abietineae ..	*Pinus Bowerbankii* Carruthers.	1884, p. 68, pl. xiv, figs. 3–8.	Abietineae ..	*Pityostrobus* sp.	Abietineous cone of uncertain relationship.
Taxodieae ..	*Sequoia Shrubsolei* Gard.	1886, p. 91, text-fig. 35 on p. 92.	Juglandaceae ?	*Petrophiloides* sp. ?	——

III. GEOLOGY

1. General Description of the London Clay

In the present work we are not concerned to make a general study of the London Clay, but only such as will be required to understand the conditions under which the fossil fruits and seeds occur, and the probable conditions under which they were deposited.

The classical work of Prestwich (1854) still maintains its position as the most authoritative account of the London Clay deposit, but valuable contributions have been made by Woodward (1887, p. 435; 1909, pp. 31–35); J. S. Gardner (1889, p. 115); and Professor A. Morley Davies (1930, p. 307).

The mass of the deposit when exposed at the surface consists of a stiff brown clay, but the colour varies according to the depth below the surface and the degree of oxidation. The Basement Bed is sandy with black flint pebbles and occasional layers of sand; the upper part of the deposit is also sandy, as it passes into the overlying Bagshot Beds. The mass of the clay is characterized by the occurrence of septaria lying in layers at irregular intervals. In thickness it " varies from a few feet in Wiltshire, and from 50 to 60 feet in Berkshire, to nearly 500 feet in the south of Essex " (Woodward, 1887, p. 435). Although a great variety of organic remains have been obtained, both animal and vegetable, they are very rarely found except in deep excavations where they have not been subjected to atmospheric influences, and in detritus on the Sheppey and Herne Bay foreshores where constant erosion continually renews the supply. Woodward suggested (1909, p. 33) that when exposed to air the iron pyrites in the clay is disintegrated, with the result that free sulphuric acid is formed, and this, acting upon calcareous fossils, destroys them, with the formation of selenite. This is very abundant throughout the deposit.

The animal remains, which consist of mammals, birds, reptiles, fishes, crustaceans, mollusca, and foraminifera, were studied by Owen, Forbes, Agassiz, F. E. Edwards, J. de C. Sowerby, Rupert Jones, and others. Of the plant remains we shall speak at length later. It will suffice to say that fruits and seeds are extremely rare *in situ*, being found, for the most part, on the shore at Sheppey and Herne Bay. Resin also and amber have rarely been found in the London Clay (pp. 5, 7), and, very rarely, *Chara* (p. 8). In the Sheppey cliffs the noticeable remains are logs and small fragments of teredo-bored wood, and smaller fragments of wood not bored; the bored wood is rendered conspicuous by the white infilling of calcite in the borings. Also calcified wood is occasionally found.

The animal remains, apart from the mollusca, are regarded as showing tropical affinity. The mollusca show affinity with both tropical and temperate types, a circumstance which Professor Morley Davies interprets as being due to the London Clay sea communicating both with the warm southern Tethys or Nummulitic Sea, and with the Northern Ocean (1930, p. 307). As we shall have occasion to refer to this question at greater length in the course of our study of the flora and climate of the London Clay, we may leave it for the present with this short statement. The foraminifera were regarded by Rupert Jones as indicating a depth of water of about 100 fathoms (Woodward, 1887, p. 437).

The above facts, taken in connexion with the character of the clay itself, have always been interpreted as indicating that the London Clay, as exemplified at Sheppey, was laid down in the sea beyond the mouth of a great river, which swept down silt and rafts of vegetation carrying animal and other debris; that after drifting in the warm sea, the larger wood drifting so long that it became teredo-bored, silt and debris together settled gently to the bottom where the sea became deep and the river current had slackened. Such an explanation will well fit in with the occurrence of the Sheppey fruits and seeds.

If we compare the Sheppey detritus with the detritus of a tropical river as described by H. N. Moseley in his account of the *Challenger* Expedition (1892, p. 373), we shall see how close the resemblance is. "On February 22nd, at noon, the ship was about 70 miles north-east of Point D'Urville, New Guinea, where the great Ambernoh River, the largest river in New Guinea, runs into the sea. This river probably rises in the Charles Louis Mountains, on the opposite side of New Guinea, which reach up to the great altitude of 16,700 feet. So large is this river that even at this great distance from its mouth, we found the sea blocked with the drift-wood brought down by it.

"We passed through long lines of drift-wood disposed in curves at right angles to the direction in which lay the river's mouth. The ship's screw had to be constantly stopped for fear it should be fouled by the wood. The logs had evidently not been very long in the water, being covered only by a few young Barnacles (*Balanus*) and Hydroids. Amongst the logs were many whole uprooted trees. I saw one of these of which the stem was two feet in diameter.

"The majority of the pieces were of small wood, branches, and small stems. . . .

"Various fruits of trees and other fragments were abundant, usually floating, confined in the midst of the small aggregations into which the floating timber was almost everywhere gathered. Amongst them were the usual littoral seeds, those of two species of Pandanus, and of a Puzzle-seed (*Xylocarpus*), fruits of *Barringtonia* and of *Ipomoea pes-capri*.

"But besides these fruits of littoral plants, there were seeds of 40 or 50 species of more inland plants. Very small seeds were as abundant as large ones, the surface scum being full of them, so that they could be scooped up in quantities with a fine net. With the seeds occurred one or two flowers, or parts of them.

"I observed an entire absence of leaves, excepting those of the Palm, on the midribs of which some of the pinnae were still present. The leaves evidently drop first to the bottom, whilst vegetable drift is floating from a shore. Thus, as the *débris* sinks in the sea-water a deposit abounding in leaves, but with few fruits and little or no wood, will be formed near shore, whilst the wood and fruits will sink to the bottom farther off land.

"Much of the wood was floating suspended vertically in the water, and most curiously, logs and short branch pieces thus floating, often occurred in separate groups, apart from the horizontally floating timber. The sunken ends of the wood were not weighted by any attached masses of soil or other load of any kind. Possibly the water penetrates certain kinds of wood more easily in one direction with regard to its growth than the other. Hence one end becomes water-logged before the other; . . .

" . . . The fruits and wood were covered with the eggs of a Gasteropod Mollusc, and with a Hydroid, and the interstices were filled with Radiolarians washed into them and gathered in masses. . . . Two species of Crabs inhabit the logs in abundance, and a small *Dendrocoele* Planarian swarms all over the drift matter and on the living crabs also. A *Lepas* was common on the logs.

" Enormous quantities of small fish swarmed under the drift-wood, and troops of Dolphins (*Coryphaena*) and small sharks (*Carcharias*), three or four feet long, were seen feeding on them, dashing in amongst the logs, splashing the water, and showing above the surface, as they darted on their prey. The older wood was bored by a *Pholas*."

To anyone who has collected systematically on the shore at Sheppey this account reads as though it were the authentic record of what had existed in the London Clay sea millions of years ago. It is true that the Eocene detritus is not concentrated in the deposit as is that of the Ambernoh River on the surface of the sea, but the detrital masses in this respect are not comparable, for one belongs to the sea-floor—at a depth of about 600 feet, as was estimated by Rupert Jones from a study of the Foraminifera—and the other to the sea-surface. But the elements of the two deposits, faunal and floral, are similar.

To return to the consideration of the deposit as a whole. Although originally occupying one continuous area the London Clay has been separated, by the action of earth movements followed by erosion, into two distinct areas known, respectively, as the London and Hampshire Basins. We need not discuss the two basins except as regards the occurrence of plant remains, to which subject we will now pass.

2. The Plant Beds of the London Clay.

From the point of view of plant remains the London Basin is very much more important than the Hampshire Basin.

(i) *The Hampshire Basin.*—Only three localities are known where plant remains have been found, and in these localities they are extremely rare.

From the lower beds of the London Clay, at Bognor on the Sussex coast, two fruits and a fragmentary leaf have been obtained by Mr. E. M. Venables after years of search. One of the fruits (V. 22724) we have determined as the endocarp of a species belonging to the family Icacinaceae. The other (V. 22792) is the seed of a vine to which we have given the name *Vitis bognorensis* n. sp. The fruits occur in a soft calcareous sandstone, the Bognor Rock, which forms a dangerous ledge running out to sea.

At Portsmouth, also from the lower beds of the London Clay, were obtained, during the excavation of docks, teredo-bored wood (Meyer, 1871, p. 75), the fruits of *Nipa*, and other doubtful plant remains (*op. cit.*, p. 77).

From Verwood, in Dorset, a leaf was obtained (Reid, C., 1902, p. 18).

(ii) *The London Basin with special reference to Sheppey and Herne Bay.*—Many localities in this area have yielded plant remains.

From the Basement Beds at Harefield, Middlesex, Mr. H. A. Toombs has obtained a number of fruits, mostly preserved as casts. Among them are *Magnolia*, the fruit of a species of Lauraceae, another fruit doubtfully referred to Euphorbiaceae, also various indeterminable fruits. From the same bed and the same locality Mr. A. G. Davis obtained a boraginaceous fruit, to which we have given the name *Davisella ehretioides* n. gen., n. sp. Although these fruits from Harefield are not as a rule beautifully preserved, they are important because so few are known from the Basement Beds.

From the Basement Bed at Watford Heath, Hertfordshire, there is a beautiful fruit (V. 6467) found by Mr. Stone of Watford. Unfortunately we were unable to determine it, so that it is described as *Carpolithus Stonei* n. sp.

Other localities where plant remains have been found in the London Basin are the following :—

From Assington, Suffolk (the exact locality is not known), John Brown (who lived 1780–1859) collected specimens from a cement stone. From an irregular lump of this stone (about as big as a man's fist) which we carefully chipped to pieces, we obtained the following four species : *Vitis minuta* n. sp., a species of Icacinaceae, two species referred to *Carpolithus*, *C. ranunculoides* and *C.* sp. 35. From the same collection Bowerbank figured and described *Mimosites Browniana* (Bowerbank, 1840, p. 140, pl. xvii, fig. 42).

From Shoeburyness, Essex, *Nipa* was obtained (V. 12907–V. 12915).

From Southend, Essex, Sowerby recorded " fruits " (1809, pp. 145–151).

From Brentwood, Essex, Mr. A. G. Davis obtained the fruit named by us *Lagenoidea trilocularis* n. gen., n. sp.

From the following London localities *Nipa* has been obtained : Copenhagen Fields (Islington), Hampstead, Whetstone, Highgate Archway, all recorded by Prestwich (1854, pp. 415, 417) ; Primrose Hill, by Bowerbank (1840, p. 15) ; Haverstock Hill (V. 7530) ; Clapham, by Mr. A. G. Davis (1928).

From near Stanmore, Middlesex, Mr. H. A. Toombs obtained a fruit of *Jenkinsella apocynoides* (V. 23093).

From Sydenham " fruits " were recorded by Sowerby (1809, pp. 145–151).

From Gravesend, Kent, Crow figured a fruit (1810, No. 544), probably belonging to the Lauraceae.

From Swale Cliff, Herne Bay, Kent, nearly all the numerous fruits of *Petrophiloides Richardsonii* were obtained by Richardson. About forty-two other species were obtained from the east end of Herne Bay by Mr. D. J. Jenkins.

From the remaining locality, the Island of Sheppey, also on the north coast of Kent, thousands of specimens belonging to some hundreds of species have been obtained. As these two localities constitute the chief sources whence we derive our knowledge of the London Clay fruits and seeds, we will devote the next section of our catalogue to their description.

Sheppey and Herne Bay.—Both localities are on the north coast of Kent, near the mouth of the Thames. The Island of Sheppey is formed by the union of three estuaries ; that of the Thames to the north, the Medway to the west, and the Swale to the south and east. Herne Bay is on the mainland to the east of Sheppey, from which it is separated by the estuary of the Swale. As the Sheppey section is the more important of the two, and is typical of both, we will first describe it.

The surface of the Island of Sheppey is undulating, the rounded hills of clay being highest towards the north of the island where, along the Thames estuary, they are cut into by the waves to form a bold cliff-section rising in some places to over two hundred feet in height. As weathered in the cliffs, the clay is dark brown in colour, fine-grained and stiff and tenacious in texture. Scattered throughout at wide intervals but still very abundant are large pieces of wood, sometimes still showing the rounded form of the tree trunks, but more often forming large irregular fragments. All are riddled with teredo-borings (usually filled with calcite), a sign that the wood drifted long in the Eocene sea before it sank. Besides the large pieces are other much smaller fragments of wood, very much more sparsely scattered. These are both better preserved than the large fragments and are not teredo-bored. Large crystals of selenite are also conspicuous in the cliffs. We were unable to find a single fruit or seed *in situ*. The cliffs are capped by a thin layer of flint gravel. According to the observations of W. H. Shrubsole, a keen local geologist, disintegration of the cliffs is produced by the combined action of land springs given out at the junction of the London Clay and overlying Bagshot Beds on the one hand, and the sea on the other, which continually eats the foot of the cliffs and sweeps away the fallen debris.

The substratum of the foreshore is clay, which is exposed over the greater part of its surface above mid-tide level, but below this level is obscured by sand and seaweed. Above the mid-tide level the surface is strewn with flint pebbles of various sizes, some quite large. These are frequently aggregated into groups, which, on account of the white colour of the flints, stand out conspicuously against the darker clay of the foreshore. The interspaces between the groups of flint pebbles are frequently strewn with small brown pebbles of concretionary pyrites, which causes them to appear as conspicuous brown patches in contrast to the groups of white flint pebbles. It is among the pyrites pebbles on these brown patches that the fossils of the London Clay occur. These, brown in colour like the pyritized nodules, consist for the most part of fruits, seeds, pyritized twigs, fragments of wood, as well as vertebrae, sharks' teeth, the pyritized casts of shells, and so on. Except the larger specimens such as *Nipa* the fruits and seeds are not easy to distinguish among the pebbles. The finding of them is greatly a matter of training the eye, as we discovered on a second visit to Sheppey in 1929 when, partly because our eyes were better trained to recognize the less peculiar forms, we collected far more specimens than we had done in the same time during a visit in 1928. In any case search has to be close and scrutinizing, so that to find the fossils it is necessary to lie or kneel upon the shore in order to distinguish them from the pyrites pebbles. Therefore, as the clay of the foreshore is wet and sticky, it is well to have a waterproof ground-sheet. The patches vary greatly in their productiveness, some being much richer than others. We found during our two visits that the Minster end of the section, the west end, was more productive than the Warden end, the east end. But this may only have been due to temporary and accidental causes. Our impression, based on the two visits of one week each, is that the richness of the deposit is extraordinary, and would even now well repay years of careful collecting undertaken by someone who would work out the species as they were found, before they had time to decay, as Bowerbank's specimens decayed and dwindled. Work such as this would almost certainly result in the knowledge of a flora of surpassing richness. Some idea of its richness may be gained from the fact that during our two short visits we collected upwards of 1,100 specimens, representing 122 species, 67 genera, and 34 families; and that of this number 30 species, 10 genera, and 3 families were new to the London Clay flora. Our own experience is confirmed by Bowerbank's statement that by going down on his hands and knees he, in one morning, collected upwards of one hundred specimens (Bowerbank, 1840 *a*, pp. 205, 206).

It is best to collect during neap-tides because, for one thing, the productive patches being above mean-tide level, a low tide is not needed in order to search for them; and in the second place the time of low water at Sheppey permits of several hours' uninterrupted collecting during the middle of the day at neap-tides, whereas at spring-tides the collecting must be divided between the beginning and end of the day, when the sun is low and visibility poor, being confused by shadows from the pebbles themselves. It is also well to collect during fine weather when the clay on the foreshore, as well as the fossils, have a chance of drying as the tide recedes. It is desirable that the fossils should be dry because moisture obscures their form and sculpture.

We have already stated that we have never seen the fossils *in situ*, and it is doubtful whether they ever have been so seen in the Sheppey cliffs. The question therefore arises as to whence they are derived. There are three possibilities: That they are washed out of the cliffs; that they are washed up from beneath the sea; that they are washed down from some locality higher up stream. The last suggestion may easily be dismissed. It is improbable to the last degree that had they been swept downstream their occurrence would exactly coincide, only and always, with the cliff-section. The second suggestion is also highly improbable because, did they derive from beneath low water, it would be along the edge of low water that they would be found; whereas actually they occur above mean-tide. The difficulty of their derivation from the cliff itself is that they have never been recorded as so found. Yet the difficulty is more apparent than real. Teredo-bored logs and small fragments of wood undoubtedly occur in the cliffs, and there can be no doubt that similar remains on the foreshore are derived from the cliffs, as are also the flint pebbles. But it is among these that the fossils are found; therefore, presumably, they also derive from the cliff. And yet they have never been seen *in situ*. The teredo-bored wood is easy to see in the cliffs because the logs are large, and the teredo-borings filled with calcite show up against the dark clay. The sparsely scattered fragments of unbored wood are small and dark, and are therefore much more difficult to find. It is only when their angular ends project that they can easily be seen in the cliff face. The rounded dark fruits would be yet more difficult to find, and their rounded forms would probably cause them to fall more quickly on exposure than the angular wood. Hence it is not so surprising that they should never have been found *in situ*. Wood and fossils alike occur on the foreshore only beneath the cliff face, and the best patches are found, for the most part, where recent falls of cliff have occurred. When the height of the cliff is taken into account, as well as the fact that with every tide masses of the soft clay are washed away; when it is remembered that the pyritized nodules and fossils on the foreshore are a mere nothing in comparison with the mass of the cliffs, and even of the newly-fallen material; when also it is realized that the fossil fruits are but few among the other pyritized remains, wood, twigs, shells, etc.; and further, when it is realized how quickly the fossils disintegrate on exposure to the air, it seems quite possible that it is because they are so sparsely scattered in the deposit that they have never been found in the cliffs, and that we owe our knowledge of them solely to the erosion by the sea and the sifting action of the tides.

The nearest claim to having traced direct connexion between the fossils and the cliffs is that of William Richardson, on whose authority Bowerbank makes the following statement. The fruits of *Petrophiloides Richardsonii* " were found during the autumn and winter of 1837, on the beach near Swale Cliff, Herne Bay, where they had been washed out from a considerable mass of clay that had recently fallen from the face of the cliff " (Bowerbank, 1840, p. 41).

Our own collections were made during two visits of one week each to Sheppey in 1928 and 1929, and one visit of one day to Herne Bay in 1930. The first visit to Sheppey, in the summer of 1928, was made during spring-tides, when we chiefly examined the shore between Eastchurch and Warden. The second visit, during neap-tides in the summer of 1929, was chiefly spent on the shore at Minster. On both occasions there had been long spells of fine weather, so that the cliff face was in a good state for observation and the fossils on the foreshore quickly dried. During the 1929 visit our much greater acquaintance with the various fossil forms, especially the more obscure and ill-preserved of these, such as the Lauraceae are apt to be, enabled us to make a much larger collection than we had made in 1928.

The only statement required with regard to the deposit at Herne Bay is that there the London Clay is less rich in fossils than at Sheppey. We owe our knowledge of the flora at this locality chiefly to assiduous collecting by Mr. D. J. Jenkins, who has obtained forty-two species from the East Cliff. Among them the following species are known only from Herne Bay: *Palmospermum Jenkinsi* n. gen., n. sp., *Palmospermum* sp. 6, *Tinospora rugosa* n. sp., *Laurocarpum* sp. 18, Lauraceae ? genus ? sp. 2, *Shrubsolea Jenkinsi* n. gen., n. sp., Anacardiaceae? genus?, *Icacinicarya Jenkinsi* n. gen., n. sp., *Sapindospermum ovoideum* n. gen., n. sp., *Sapindospermum Jenkinsi* n. sp.

We spent one day collecting at Swale Cliff, to the west of Herne Bay. But, although pieces of wood and twigs were abundant, both on the shore and in the cliff, we found but few other fossils: A few mollusca, one fish vertebra, a coral and one coccus of *Wetherellia*. It is noticeable that we found no specimen of *Nipa*, which is so abundant at Sheppey only ten miles away.

IV. THE PRACTICAL STUDY OF THE LONDON CLAY FRUITS AND SEEDS

1. General Considerations as to Methods of Palaeobotanical Research

(i) *Collection of Living Material for Comparison.*—The degree of comparison possible between living and fossil material depends primarily upon two things : The state of preservation of the fossils, including the amount of material preserved ; and the supply of living material available for comparison. But it further depends on the degree of research expended both on the fossil and living material.

In following the researches of others in Tertiary Palaeobotany we have frequently encountered a difficulty which, no doubt, others have met with, in our own work—the difficulty of knowing on what degree of research, either among the fossils themselves or among the corresponding parts of living plants, the determination of the fossil forms is based. It is obvious that the value of any determination must rest on the degree in which the fossil plants have been studied, and upon the comprehensiveness of the comparison made with living forms.

Long continued collection, study, and classification of floral organs by botanists has made the study of these organs very comprehensive, and has rendered the determination of species, by reference to them, comparatively easy for the student. But similar study and classification has not been extended to the fruits and seeds of plants. In many cases these are neither adequately described and figured, nor represented in herbaria ; consequently knowledge of their form and structure is limited, and difficult of attainment. In view of these considerations it is desirable to state what degree of research among living forms has preceded our work on the fruits and seeds of the London Clay.

Following upon the initial researches and collections of Clement Reid, the authors have gradually amassed a collection of living seeds and, in a lesser degree, of fruits, which they have tried to make representative of all families and as many genera as possible, and to illustrate the genera by a variety of species. Naturally it has not been possible to carry out this scheme adequately, and it has therefore been necessary to supplement the knowledge to be derived from the collection by making working drawings of fruits and seeds. The number of such drawings now amounts to several thousands.

It so happened that the earlier work lay among the plants of the later Tertiary deposits—periods when the conditions were temperate or warm temperate. The fruits and seeds of temperate and warm temperate plants of the Northern Hemisphere were therefore the first to be collected and drawn. Gradually as, again by pure chance, older deposits came to be studied, in which warmer conditions were indicated, the same methods of obtaining knowledge of living material (collections and drawings) were extended towards the plants of warmer and warmer regions. But until we undertook the study of the London Clay fruits and seeds it was not found necessary to make any considerable study of tropical forms. It may be noted incidentally that the purely accidental order of research from the newer to the older Tertiaries meant continually passing backward in time from the known to the unknown.

When we undertook the study of the London Clay fruits and seeds we were confronted for the first time with a large flora believed to have tropical affinities, as indicated by Ettingshausen's list of species (most erroneous as it has turned out to be) and the known occurrence of *Nipa*. Consequently it became necessary to acquaint ourselves as fully as might be with the fruits and seeds of tropical plants.

The work was begun in Kew Herbarium in 1926. Guided by our previous knowledge of some of the well characterized forms which we were able to recognize among the London Clay fossils, we began by making special studies and drawings of the families to which these belonged. They were the Menispermaceae, Anonaceae, Icacinaceae, Magnoliaceae, Sapindaceae, Sapotaceae, and Anacardiaceae. This preliminary work led definitely to the conclusion that the allies of the London Clay plants were tropical and that the greater part were plants of Indo-Malaya, but that the alliance also included tropical plants of the whole world. Many weeks were spent during 1926 and the following years in making thousands of studies from the living forms. At the same time we added to our tropical collection as far as we could; and for our ability to do this we are particularly indebted to the authorities of the Royal Gardens, Kew, and the Royal Botanic Gardens, Edinburgh. By the generosity of the Kew authorities we were also enabled to make more intimate and detailed examination of many fossil and living species side by side under the microscope, through the loan of specimens from the Herbarium. Usually it was by reference to our own collection of living forms and to our drawings that we were enabled to make preliminary suggestions as to relationship, but full comparison was always afterwards made with material in Kew. When an alliance with one or more families was suggested, we then, in Kew Herbarium, made as intensive a study of the family or families as possible. The results of such studies will be found in the systematic descriptions. The greater number of the fossil species proved to belong to living families, and many belong to living genera.

(ii) *Use of the Material: Diagnostic Characters.*—There are two categories under which the diagnostic characters of fruits and seeds may be grouped: External Characters and Anatomical Characters.

(*a*) **External characters.**—The most obvious of these characters, moreover, one on which too great a dependence has not infrequently been laid, is the general appearance. General appearance may offer an invaluable clue to the botanical position of a fruit or seed, but it is greatly to be deprecated that it alone should be used as a trustworthy guide for determination. There are cases, it is true, where fruits and seeds are so well characterized either by peculiar form, or sculpture, or marked appendages such as wings, spurs, etc., that it may be possible to make accurate generic, or even specific, determinations, from external appearance only, if the fossil material is well preserved. We have in mind such remarkably shaped endocarps as those of *Martynia*, or some of the Menispermaceae; such distinctively shaped and sculptured endocarps as those of *Ranunculus*, *Rubus*, or the Icacinaceae; or seeds like those of *Vitis*, *Actinidia*, the Caryophyllaceae and Passifloraceae; or, again, winged fruits like those of *Dipelta*, *Engelhardtia*, *Ulmus*, and *Acer*; or winged seeds like those of the Bignoniaceae; or spined fruits like those of *Ceratophyllum*, *Trapa*, etc. Yet even so it is wise to make as thorough a microscopical examination and study as possible. And if it is not possible, and the fossil is not well characterized by any peculiar external features, it may be better neither to figure nor describe it, and certainly not to determine it. How misleading dependence on mere external appearance may be is shown in relation to the present work, for Ettingshausen's endlessly confused and mistaken determinations obviously have arisen from their being based on external appearance without reference to anatomical and microscopical characters. But if to the character of outward form be added a careful microscopical study of the surface; and if, in fruits, the number of carpels, the arrangement of the carpellary organs, and method of dehiscence can be inferred; and, in seeds, the manner of germination and the arrangement of the seminal organs, then the outward characters may be very valuable.

Yet outward appearance, if untrustworthy as the only determinant character, may furnish valuable clues for further research. And, alone, it may narrow the search to a few families, or possibly a few genera.

(*b*) **Anatomical characters.**—Anatomical characters of fruits and seeds are among the most reliable, because among the most stable and persistent inheritances from the past. Those which we have found to be of the most value are: (α) The mode of germination; (β) the arrangement of the various carpellary and seminal organs; (γ) the structure and succession of the various integuments whether of fruit or seed.

(α) *The Mode of Germination.*—The study of fossil fruits and seeds has shown that the mode of germination is one of the most characteristic of plant inheritances. The processes of fossilization, when they include prolonged maceration and the protracted application of pressure, cause hard woody fruits and seeds to yield along their natural planes of weakness, and the most important of these planes are those associated with germination. Consequently the mode of germination is frequently exhibited by fossils with a degree of perfection which cannot be attained in living material except by actual germination. But germinated woody fruits and seeds are not often found in herbaria. And, even if there be spare material available, it is not easy to induce artificial germination; although this sometimes can be induced by prolonged maceration and pressure. Nevertheless, with the aid of the fossil material to show the way, it is usually possible by careful study to trace in the living what is the mode of germination, without resorting either to natural or artificial means of exhibiting it. Usually on the surface, or in sections, if there are such, some faint indications of grooves or the alignment of cells and fibres will serve to show the outline of valves and plugs. Thus when fruits dehisce by valves these are usually (? always) associated with the arrangement of the fibro-vascular bundles of the carpels. When, again, hard endocarps throw off partial valves (Nyssaceae, Burseraceae), or extrude plugs (Anacardiaceae), the form of these valves or plugs is generally indicated by a slight groove or by the swerving of fibro-vascular bundles. It may be observed in passing that such partial valves and plugs are usually in close relationship with the micropyle and radicle of the seed. The fruit acts, as it were, under the influence of the seed. Seeds also may exhibit surface indications of similar methods of germination by valves (*Decodon*), or by plugs (Nymphaeaceae, *Aldrovanda*).

(β) *Arrangement of the Carpellary and Seminal Organs.*—The arrangements of the various organs within the fruit and seed are extremely valuable indications of relationship, because they are as stable and persistent as the modes of germination. The arrangements we speak of are, in the fruit, the relative positions of the attachment and style, and the way in which the fibro-vascular bundles enter the fruit and are carried through the various carpellary coats to the placenta, and thence to the seed; also the arrangement of the seed itself within the fruit. Similarly, in the seed, there are the relative positions of the hilum, raphe, chalaza and micropyle, both in regard to one another and to the fruit.

(γ) *Structure and Succession of the Integuments.*—The structure and succession of the integuments of fruit and seed and of the coats which form them is another extremely valuable criterion of relationship. In living material it is easy to study these by cutting sections, although they may also be studied by means of fractures and dissections. When examining a large mass of fossil material (such as a large flora), although it may (or may not) be possible to produce plane or thin sections, the method of fracture and dissection is to be preferred as being incomparably quicker than the sectional method, and as furnishing information which cannot otherwise be obtained. In studying *Petrophiloides* we used both methods, because the evidence for placing it with the Juglandaceae, although we had already satisfied ourselves of its position by dissection, could only be demonstrated conclusively by serial sections. But to carry out such studies for a whole flora, besides being prohibitive, is unnecessary, because fracture, artificial or natural, and dissection, will frequently give much more quickly and effectively the desired information as to the structure and succession of the various coats, whether of fruit or seed. By this means the coats can often be studied not only in sectional, but in surface view also. The reason for this is that in fossilized fruits and seeds the fusion of successive coats, which in life may appear complete, tends to be dissolved by the processes of maceration and decay, the separation being yet further emphasized by the intercalation of layers or films of matrix. Consequently the structure as well as the succession of coats can often be more readily observed and more completely studied in the fossil than in the living.

We will now apply these methods of study to the London Clay fruits and seeds.

2. Application of the above Considerations to the Study of the London Clay Fruits and Seeds

(i) *Mode of Preservation of the London Clay Fruits and Seeds.*—Before we can discuss the possibility of using the above-mentioned diagnostic characters in relation to the London Clay fossils we must first describe the mode in which these are preserved.

The preservation of the tissues is often remarkably perfect. Sometimes they are still carbonized, the carbonized matter being impregnated with pyrites, and all cavities, whether locules, seed-, or cell-cavities, or the interspaces between the various coats and integuments, being filled with pyrites. It will readily be understood that in such specimens there is a succession of soft and hard layers and an intermixture of soft and hard substances. This, and the instability of the pyrites itself, on exposure to the air, tends to rapid decay of the specimens and also leads to very great abrasion when the fossils are buffeted by the waves. In other specimens the tissues are entirely replaced by pyrites, cell by cell, so that the whole structure, as well as all cavities, are preserved in pyrites. In such specimens the surfaces of the cells, and consequently the surfaces of the coats and integuments, may be indicated by their glittering golden appearance, an appearance which the pyrites takes on when it has been in contact with a smooth glossy surface. Other very common modes of fossilization are found in combinations of pyritized and carbonized tissues. The same coat may in one part be wholly pyritized, in another wholly carbonaceous, and in yet another may be an admixture of the two. Again, a wholly pyritized coat may be succeeded by a carbonaceous one, and when this happens the rotten carbonaceous coat tends to disintegrate, the specimen falling to pieces. By such a process successive integuments are exposed and can be studied, affording one of the most valuable means of discovering the anatomical characters.

Another cause which frequently enables the concentric shells forming the integuments of the London Clay fossils to be clearly differentiated and rendered available for surface, as well as sectional study, is one we have already alluded to, namely, that during the process of fossilization, apparently before mineralization began, the prolonged maceration which the fossils underwent caused the separation of coats which in the living appear to be fused. Natural maceration has done what even prolonged maceration in nitric acid will only partially effect in living forms. This was particularly well exemplified in specimens of *Tricarpellites communis* when compared with *Canarium*. One of the most remarkable of the coats of *T. communis* is that described by Bowerbank as a "beautifully reticulated layer." The term exactly describes it; and in the fossil it is most conspicuous. It forms the middle coat of the endocarp. Although we had traced in the living all the other coats seen in the fossil, we could find no sign of this, which in the fossil separates freely from the others. It was only after many weeks of maceration in nitric acid that we were able at last adequately to expose the coat.

There is another result which frequently follows from the separation of coats by maceration. We have already spoken of the layers of pyrites sometimes intercalated between successive integuments, and of the glittering contact impressions made by the cells. In consequence the surfaces of the layers or films constantly show most perfect impressions of the overlying and underlying tissues; and these can be studied under the microscope exactly as though they were the surfaces of the tissues themselves. Similar contact impressions are also found on the casts of cavities such as locules and seed-cavities.

A word of caution may be advanced as to the occurrence of these films and internal casts with their beautiful cell-impressions. These, to a considerable extent, were the cause of Bowerbank's mistakes and misreadings of the successive coats in some of his species. The impressions are often so perfect, and the form of the cavity so exactly moulded that the films and casts appear to form the actual substance of the fruits and seeds. Only in section can the falsity of the appearance be recognized. Hence, till constant study enables one to recognize the appearance of these surface impressions, it is well to test their nature by sectioning the specimens. We can speak feelingly of the errors into which the presence of these shells and films can lead the student, because again and again at the beginning of our study we fell into mistakes which resulted entirely from our failure to recognize their inorganic nature. The observation by Starkie Gardner of the infillings of pyrites between the scales of *Petrophiloides Richardsonii* (*Alnus* of Gardner) first suggested to us the wider occurrence of the phenomenon of infiltration to which we have alluded above. But there are other results of infiltration in the London Clay; it may cause succulent parts of soft fruits to remain distended as in life (e.g. the pulp-cells in the exocarps of some Lauraceae and the placenta of *Oncoba*), parts which are very rarely preserved fossil.

Sometimes infiltrated pyrites may act as a cement, fusing parts which are naturally separate. Thus cocci may be fused, carpel and seed, tegmen and testa, or, as in some of the Lythraceae, Nymphaeaceae, Saxifragaceae, and other many-seeded fruits, the seeds may be cemented into a solid mass, which may remain as a free solid entity when the carpel wall which contained it has perished.

When either disruption or fusion has occurred, misinterpretation of the structure is likely to follow. One especial cause of mistake we found to arise from the intercalation of thin layers of pyrites along lines or planes of weakness, for example, the gaping margins of valves in loculicidal fruits. When such intercalations have occurred and, as often happens, the valves themselves have perished, there remains an internal cast with longitudinal ridges in the position of the loculicidal splits. The result being that the specimen simulates a ribbed fruit. It is impossible to tell except by sectioning such specimens, so that experience is gained, whether one is dealing with a fruit or an internal cast, for the exterior may bear beautiful impressions of cells. Experience, however, is informative. If the specimen is a fruit, the ribs will usually be fibrous, if a locule-cast, they will be formed of pyrites.

Before leaving the subject of the preservation of the London Clay fruits and seeds we must mention that very rarely the fossils have been found preserved in calcite. In this case the calcite has infiltrated exactly as has the pyrites in the more common form of preservation. It must also be noted that the fruits of *Nipa*, although pyritized, frequently have the cavity filled by a siliceous sandy matrix.

(ii) *Diagnostic Characters preserved, and the Methods of Study.*—We may now discuss in what degree and in what manner it has been possible to make use of the various diagnostic characters described above, in the study of the London Clay fossils.

(*a*) **External Characters of the London Clay Fruits and Seeds.**—It will be recognized from the above accounts of the state of preservation of the London Clay fruits and seeds and the mode of their occurrence on the Sheppey foreshore, that they must necessarily have suffered great abrasion. Consequently the external form and characters are usually much damaged. Not infrequently the softer, partly carbonized coats have been wholly or partially abraded, leaving only the hard pyritized casts of locules or seeds with, it may be, small fragments of the integuments which have escaped destruction. Therefore, external characters are not only as a rule useless for diagnostic purposes, but may be most misleading. There are exceptions, when the exterior coats have partially, at least, escaped destruction, and then it has been possible to measure and study the cells of which they are composed, but only very rarely has a fossil been found with its outer integument intact. For the main indication of relationship it has been necessary to rely upon other characters.

(*b*) **Anatomical Characters.**—We have seen that the external characters of the London Clay fruits and seeds are little to be relied on as of diagnostic value. It has therefore been necessary to devise the best means of studying their anatomical characters. The method of Crow (p. 5) and of Bowerbank is the only one to be followed if the determinations are to be more than guesswork. The fossils must be opened and their structure revealed. We have found that the most informative method of procedure is not that of cutting sections. It is much too slow when thousands of specimens have to be examined, many of which cannot even be sorted without examining their internal structure. Besides, in the case of fossils preserved as are those of the London Clay, sectioning is apt to result in smeared surfaces. We therefore adopted the method of fracturing the specimens by the use of cutting-pliers such as are used for cutting tiles. We procured a powerful pair for making the first fractures, and a smaller, more delicate pair for nipping off small fragments when it was desired to expose some particular organ or integument. In using the pliers it is desirable generally to attempt to fracture the fossil (that is to apply the pressure) in the direction of the supposed planes of weakness. The reason for this is that, almost certainly, in some part at least, the fruit will yield along one or more of its planes of weakness, thus revealing its mode of germination, and sometimes the course of the nutrient vessels through the coats of fruit, or seed, or both. Hence it may become possible to trace the number of locules, the manner of germination and placentation, and the positions of the various organs of the seed. This is of great importance because these are characters which, either collectively or in part, are often among those which are used in the classification of living plants. Therefore knowledge of them has constantly enabled us to make use of works on systematic botany as an aid in our determinations. Nevertheless we have always checked determinations thus made by actual comparison of the fossils with living material.

Sectioning with pliers does not, however, always yield such happy results, chiefly because the outward form of the fossil is often so obscured by decay, abrasion, distortion, or accretions of pyrites, that it is impossible even to make a guess at the structure of the specimen. Sectioning must then be purely haphazard. Yet even so, it will generally happen that a plane of weakness yields and gives a hint as to how further dissection should be attempted in order to afford the best results.

For the study of integuments, their structure and succession, irregular fractures are more useful than those along natural planes of weakness. Very commonly when fracturing a specimen parts of the integuments chip or flake away so that both sectional and superficial surfaces can be studied in successive coats. We have as far as possible measured the cells which form various coats. Not that we have found such measurements always to be uniform for any coat, or always to be of specific value, although sometimes doubtless they are (Euphorbiaceae, for instance). But at least the measurements serve as a scale for comparison, and therefore as a check.

Thus it is seen that owing to the way in which the London Clay fruits and seeds are preserved it is possible by following suitable methods of research to study some or all of the diagnostic characters named above (see pp. 27–29). But the degree in which these can be used in individual species depends on the amount of material available as well as on the state of preservation of that material. One specimen may show characters either lost, or not demonstrable in others. We may note that because of this it has proved impossible to base determinations on the evidence offered by the type specimen alone. The evidence has had to be drawn from every available source. The type has sometimes been selected because it was the most perfect specimen, but the conclusive evidence of anatomy will often have been derived from damaged or decaying specimens.

There are one or two further remarks that it is desirable to make as to the treatment of the material. Owing to the mixture of carbonaceous matter and pyrites, surfaces very easily become smeared, so that it is impossible to examine them microscopically. It is then best to sacrifice the crumbling carbonaceous matter and to clean the surfaces by brushing them sharply with methylated spirit, so that the pyritized cells, or the imprint of cells on the pyritized surface can be studied.

With regard to the preservation of the fossils for laboratory work, we have found that glycerine is the best substance. Originally they were preserved in linseed oil, and at first we continued to use it. But, as it is utterly impossible to study wet fossils, because moisture obscures even the most conspicuous features, we had to dry them again and again—to get a general idea of their appearance for a preliminary sorting, to study them in more detail, to look for characters found in other specimens, to compare them with living forms, to search for diagnostic characters perhaps seen in the living but not in the fossil, to photograph them, and so on. Such requirements made it more and more impossible to deal with them when preserved in linseed oil. For the oil clogs, and forms gluey films and blobs, not only on the surface but within the substance of the fossil, obscuring all its features. To rid it of this gluey substance, prolonged soaking in petrol and afterwards in methylated spirit was found to be best, followed by brushing with spirit. But the labour and time required were prohibitive, and we tried other methods.

Quite accidentally we discovered that glycerine was as effective in preventing decay as linseed oil. Moreover, it has the advantage that it is soluble in water and can be washed off. From water the specimens can be transferred to methylated spirit and then easily dried. The process of drying is quick and clean and can readily be repeated any number of times. We, therefore, after cleaning the fossils from linseed oil, transferred the whole collection into glycerine.

V. BOTANY

We now pass to the consideration of the results which have accrued from the study of the London Clay fruits and seeds, beginning with a list of the species which are described in the systematic part of the catalogue. Excluding diatoms, 234 named species are recorded, and eighty doubtful and unnamed species.

In this list (*a*) denotes that we have seen one at least of the actual specimens figured by Bowerbank or Gardner; (*b*) denotes that we have seen no specimens, but that the original figures and descriptions make us confident that the relationship is as suggested below and not as suggested by the original authors; (*c*) denotes that we have seen specimens, but do not recognize among them types or figured specimens of the original authors.

A.=Assington,
B.=Bognor Rock,
Br.=Brentwood,
C.=Clapham,
C.I.=Copenhagen Fields, Islington,
F.=Faversham,
H.=Harefield,
H.B.=Herne Bay,
H.H.=Haverstock Hill,
Hi.=Highgate Archway,
P.=Primrose Hill,
S.=Sheppey,
Sh.=Shoeburyness,
So.=Southend,
St.=Stanmore,
W.=Watford Heath.

The approximate numbers of specimens belonging to each species are also given. ∞ denotes more than 400, too numerous to count; + indicates fragments or additional doubtful specimens.

1. List of Species

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Diatomeae	Diatoms, various.	—	S., So., etc.
Charophyta	*Chara medicaginula* (Lamarck).	—	C.I.
,,	,, sp.	—	C.I.
Araucarineae	(*c*) *Araucarites* sp.	6	S.
Abietineae	(*b*) *Pityostrobus* sp.	—	S.
Cupressineae	(*c*) *Cupressinites curtus* Bowerb.	2	S.
Taxaceae	*Cephalotaxus Bowerbanki* n. sp.	2	S.
Taxaceae ?	Genus ?	1	S.
Coniferae (family ?)	*Cupressinoxylon Holdenae* Seward.	—	F.
Palmae (section Oncospermeae)	*Oncosperma ? anglica* n. sp.	1	S.
,, (section Caryotideae) ..	*Caryotispermum cantiense* n. gen. & sp.	1	S.
,, (section Corypheae) ..	*Sabal grandisperma* n. sp.	2	S.
,, ,,	,, sp. (*grandisperma ?*) .	3	S.
,, ,,	*Serenoa eocenica* n. sp.	3	S.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Palmae (section Corypheae) ..	*Serenoa* sp. ?	I	S.
,, ,,	*Livistona ? minima* n. sp.	I	S.
,, (section unknown) ..	*Palmospermum Jenkinsi* n. gen. & sp.	I	H.B.
,, ,,	,, *excavatum* n. sp.	4+	S., H.B. ?
,, ,,	,, *parvum* n. sp.	I	S.
,, ,,	,, *minimum* n. sp.	2	S.
,, ,,	,, *pusillum* n. sp.	8	S.
,, ,,	,, sp. 6.	I	H.B.
Palmae ? ,,	*Palmospermum ?* sp. 7.	3	S.
,, ,,	,, sp. 7 ?	2	S.
Nipaceae	(*a*) *Nipa Burtini* (Brongn.).	∞	C., H.H., Hi., P., S., Sh., etc.
Juglandaceae	(*a*) *Petrophiloides Richardsonii* Bowerb.	300	H.B., S.
,,	*Juglandicarya Lubbocki* n. gen. & sp.	2	S.
,,	,, *cantia* n. sp.	2	S.
,,	,, *depressa* n. sp.	20	S.
,,	(*b*) ,, *crassa* (Bowerb.).	I	S.
Urticaceae ?	*Urticicarpum scutellum* n. gen. & sp.	I	S.
Olacaceae	*Erythropalum europaeum* n. sp.	6	S.
,,	*Erythropalum* (*?*) *striatum* n. sp.	21	S.
,,	*Olax depressa* n. sp.	2	S.
Olacaceae ?	Genus ?	I	S.
Nymphaeaceae..	*Protobarclaya eocenica* n. gen. & sp.	I	S.
Trochodendraceae	*Trochodendron ? pauciseminum* n. sp.	I	S.
Menispermaceae—			
,, (section Triclisieae)	*Bowerbankella tiliacoroidea* n. gen. & sp.	5	S.
,, (section Fibraureae)	*Tinomiscoidea scaphiformis* n. gen. & sp.	4	S.
,, ,,	*Microtinomiscium foveolatum* n. gen. & sp.	I	S.
(section Tinosporeae)	*Tinospora excavata* n. sp.	40	S., H.B.
,, ,,	,, *rugosa* n. sp.	I	H.B.
,, (section Cocculeae)	*Eohypserpa Parsonsi* n. gen. & sp.	16	S.
Magnoliaceae	(*a*) *Magnolia longissima* (Bowerb.).	I (+ ?)	S.
,,	(*a*) ,, *lobata* (Bowerb.).	12+	S.
,,	(*a*) ,, *subquadrangularis* (Bowerb.).	2	S.
,,	,, *crassa* n. sp.	2	S.
,,	,, *subtriangularis* n. sp.	2	S.
,,	,, *angusta* n. sp.	14+	S.
,,	,, *angusta ?*	I	H.
,,	,, *subcircularis* n. sp.	4	S.
,,	(*b*) ,, *enormis* (Bowerb.).	I	S.
,,	,, sp.	I	S.
Anonaceae	*Anonaspermum commune* n. sp.	65	S.
,,	,, *rotundatum* n. sp.	18	S.
,,	,, *rugosum* n. sp.	8	S.
,,	,, *pulchrum* n. sp.	3	S.
,,	,, *minimum* n. sp.	3	S.
,,	,, *punctatum* n. sp.	12	S.
,,	,, *ovale* n. sp.	4	S.
,,	,, *complanatum* n. sp.	4	S.
,,	,, *corrugatum* n. sp.	8	S.
,,	,, *anoniforme* n. sp.	2	S.
,,	,, *subcompressum* n. sp.	I	S.
,,	,, *obscurum* n. sp.	I	S.
,,	,, *cerebellatum* n. sp.	I	S.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Lauraceae	*Endiandra crassa* n. sp.	7	S.
,,	*Cinnamomum globulare* n. sp.	40	S., H.B.
,,	,, *grande* n. sp.	5	S., H.B.
,,	*Litsea pyriformis* n. sp.	4	S.
,,	(? *a*) *Beilschmiedia oviformis* (Bowerb.).	9	S.
,,	,, *pyriformis* n. sp.	14	S.
,,	,, *Bowerbanki* n. sp.	1	S.
,,	,, *eocenica* n. sp.	6	S.
,,	,, *gigantea* n. sp.	3	S.
,,	,, ? (or *Endiandra ?*) *crassicuta* n. sp.	4	S.
,,	,, (or *Endiandra ?*) *fibrosa* n. sp.	1	S.
,,	*Protoravensara sheppeyensis* n. gen. & sp.	4	S., H.B.
,,	(*a*) *Crowella globosa* (Bowerb.) n. gen.	13	S.
,,	*Laurocalyx globularis* n. gen. & sp.	1	S.
,,	,, *fibrotorulosus* n. sp.	1	S.
,,	,, *dubius* n. sp.	1	S.
,,	,, *Bowerbanki* n. sp.	1	S.
,,	,, *magnus* n. sp.	1	S.
,,	*Laurocarpum sheppeyense* n. gen. & sp.	20	S.
,,	,, *paradoxum* n. sp.	80	S.
,,	,, *ovoideum* n. sp.	4	S.
,,	,, *proteum* n. sp.	9	S.
,,	,, *minutissimum* n. sp.	4	S.
,,	,, *minimum* n. sp.	4	S.
,,	,, *pyrocarpum* n. sp.	2	S.
,,	,, *crassum* n. sp.	2	S.
,,	,, spp. 9–20.	52	Spp. 16 and 18 H.B.; sp. 20 H.; others S.
Lauraceae ?	? *Laurocarpum* sp. 21.	1	S.
,,	,, sp. 22.	1	S.
,,	Genus ? sp. 1.	1	S.
,,	,, sp. 2.	1	H.B.
Saxifragaceae	*Saxifragispermum spinosissimum* n. gen. & sp.	2	S.
Hamamelidaceae	*Protaltingia europaea* n. gen. & sp.	1	S.
,,	Genus ?	1	S.
Leguminosae	(*a*) *Mimosites Brownianus* Bowerb.	1	A.
Linaceae	(*c*) *Wetherellia variabilis* Bowerb.	∞	S., H.B.
,,	*Decaplatyspermum Bowerbanki* n. gen. & sp.	1	S.
Rutaceae	*Canticarya sheppeyensis* n. gen. & sp.	12	S.
,,	,, *ventricosa* n. sp.	8	S.
,,	,, *ovalis* n. sp.	3	S.
,,	,, *gracilis* n. sp.	1	S.
,,	*Shrubsolea Jenkinsi* n. gen. & sp.	1	H.B.
,,	*Eozanthoxylon glandulosum* n. gen. & sp.	1	S.
,,	*Clausenispermum dubium* n. gen. & sp.	2	S.
Rutaceae ?	*Caxtonia glandulosa* n. gen. & sp.	13	S.
,,	,, *rutacaeformis* n. sp.	1	S.
Burseraceae	(*c*) *Tricarpellites communis* Bowerb.	41	S., H.B.
,,	*Protocommiphora europaea* n. gen. & sp.	19+	S.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Burseraceae	*Bursericarpum angulatum* n. gen. & sp.	1	S.
Meliaceae	(*c*) *Toona sulcata* (Bowerb.).	12	S.
,,	*Melicarya variabilis* n. gen. & sp.	5	S.
Meliaceae ?	Genus ?	1	S.
Euphorbiaceae	(*a*) *Euphorbiotheca sheppeyensis* n. gen. & sp.	1	S.
,,	,, *obovata* n. sp.	1	S.
,,	,, *minor* n. sp.	1	S.
,,	,, *obscura* n. sp.	2	S.
,,	,, ? *pentalocularis* n. sp.	1	S.
,,	*Euphorbiospermum eocenicum* n. gen. & sp.	12	S., H.B.
,,	,, *subquadratum* n. sp.	1	S.
,,	,, *truncatum* n. sp.	2	S.
,,	,, *obliquum* n. sp.	1	S.
,,	,, *obtusum* n. sp.	1	S.
,,	,, *subovoideum* n. sp.	2	S.
,,	,, *ambiguum* n. sp.	3	S.
,,	,, *latum* n. sp.	2	S.
,,	,, *crassitestum* n. sp.	2	S.
Euphorbiaceae ?	Genus ?	1	H.
Anacardiaceae— (section Spondieae)	*Dracontomelon subglobosum* n. sp.	20	S., H.B.
,, ,,	,, *minimum* n. sp.	38	S.
,, ,,	*Pseudosclerocarya lentiformis* n. gen. & sp.	3	S.
,, ,,	,, *subalata* n. sp.	1	S.
,, ,,	*Spondias sheppeyensis* n. sp.	1	S.
,, ,,	*Spondicarya trilocularis* n. gen. & sp.	1	S.
,, ,,	*Odina Jenkinsi* n. sp.	1 (+1 ?)	H.B.
,, ,,	,, *europaea* n. sp.	2	S.
,, ,,	,, (?) *subreniformis* n. sp.	1	S.
,, ,,	*Xylocarya trilocularis* n. gen. & sp.	1	S.
,, ,,	Genus ?	1	S.
Anacardiaceae ?	*Lobaticarpum variabile* n. gen. & sp.	16	S.
,,	Genus ?	1	H.B.
Celastraceae	*Cathispermum pulchrum* n. gen. & sp.	2	S.
,,	*Canticarpum celastroides* n. gen. & sp.	1	S.
Icacinaceae (section Iodeae) ..	*Iodes corniculata* n. sp.	63	S., H.B.
,, ,,	,, *multireticulata* n. sp.	106	S., H.B.
,, ,,	,, *eocenica* n. sp.	3	S.
,, ,,	,, sp. ?	1	A.
,, ,,	(*a*) *Sphaeriodes ventricosa* (Bowerb.) n. gen.	49	S.
Icacinaceae— (section Phytocreneae)	*Palaeophytocrene foveolata* n. gen. & sp.	24	S.
,, ,,	,, *foveolata* var. *minima* nov.	6	S.
,, ,,	,, *ambigua* n. sp.	1	S.
,, ,,	*Stizocarya communis* n. gen. & sp.	180	S.
,, ,,	,, *oviformis* n. sp.	1	S.
Icacinaceae (section not known)	(*a*) *Faboidea crassicutis* Bowerb.	124	S., H.B.
,, ,,	*Icacinicarya platycarpa* n. gen. & sp.	100	S.
,, ,,	,, *ovoidea* n. sp.	2	S.
,, ,,	,, *ovalis* n. sp.	4	S.
,, ,,	,, *nodulifera* n. sp.	3	S., H.B.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Icacinaceae (section not known)	*Icacinicarya foveolata* n. sp.	2	S.
,, ,,	,, *minima* n. sp.	17	S.
,, ,,	,, *Jenkinsi* n. sp.	1	H.B.
,, ,,	(*b*) ,, *elegans* (Bowerb.).	1	S.
,, ,,	(*c*) ,, *rotundata* (Bowerb.).	2	S.
,, ,,	,, *bognorensis* n. sp.	1	B.
,, ,,	,, spp. 11, 12.	2	S.
,, ,,	Various, indeterminable, including (*a*) "*Ginkgo eocenica* Gardner" and "*Amygdalus* sp. n. 2" of Ettingshausen.		S.
Icacinaceae ?	Genus ?	1	S.
Sapindaceae	*Palaeallophylus ovoideus* n. gen. & sp.	97	S.
,,	,, *rotundatus* n. sp.	1	S.
,,	*Palaealectryon spirale* n. gen. & sp.	3	S.
,,	(*a*) *Cupanoides tumidus* Bowerb.	6	S.
,,	(*a*) ,, *grandis* Bowerb.	45	S.
,,	*Sapindospermum ovoideum* n. gen. & sp.	1	H.B.
,,	,, *Jenkinsi* n. sp.	1	H.B.
,,	,, *grande* n. sp.	1	S.
,,	,, sp. 4.	1	S.
,,	(*b*) ,, (?) *subovatum* (Bowerb.).	1	S.
,,	Genus ?	1	S.
Sabiaceae	*Meliosma Jenkinsi* n. sp.	6	S., H.B.
,,	,, *cantiensis* n. sp.	39	S., H.B.
,,	,, *sheppeyensis* n. sp.	3	S.
Vitaceae	*Vitis subglobosa* n. sp.	2	S., H.B.
,,	,, *semenlabruscoides* n. sp.	2	S.
,,	,, *minuta* n. sp.	1	A.
,,	,, *bognorensis* n. sp.	2	B.
,,	*Tetrastigma globosa* n. sp.	2	S.
,,	,, ? *longisulcata* n. sp.	1	S.
,,	*Ampelopsis crenulata* n. sp.	2	S.
,,	,, *rotundata* n. sp.	2	S.
,,	*Cayratia ? monasteriensis* n. sp.	2	S.
,,	*Palaeovitis paradoxa* n. gen. & sp.	10	S.
Elaeocarpaceae	*Echinocarpus priscus* n. sp.	5	S., H.B.
,,	,, *sheppeyensis* n. sp.	1	S.
Tiliaceae	*Cantitilia polysperma* n. gen. & sp.	115+	S., H.B.
Sterculiaceae (section Dombeyeae ?)	*Sphinxia ovalis* n. gen. & sp.	4	S., H.B.
Dilleniaceae	*Tetracera eocenica* n. sp.	16	S.
,,	,, ? *cantiensis* n. sp.	1	S.
,,	,, ? *sheppeyensis* n. sp.	1	S.
Ternstroemiaceae ?	Genus ?	1	S.
Flacourtiaceae	(*a*) *Oncoba variabilis* (Bowerb.).	70+	S.
,,	*Oncobella polysperma* n. gen. & sp.	1	S.
Haloragaceae	*Haloragicarya quadrilocularis* n. gen. & sp.	1	S.
Lythraceae	*Minsterocarpum alatum* n. gen. & sp.	5	S.
,,	*Pachyspermum quinqueloculare* n. gen. & sp.	1	S.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Lythraceae ?	*Tamesicarpum polyspermum* n. gen. & sp. (?=*Cupressinites corrugatus* Bowerb.).	20+	S.
,,	*Cranmeria trilocularis* n. gen. & sp.	2	S.
Onagraceae	*Palaeeucharidium cellulare* n. gen. & sp.	1	S.
Nyssaceae	*Protonyssa bilocularis* n. gen. & sp.	3	S.
,,	*Palaeonyssa multilocularis* n. gen. & sp.	4	S.
,,	,, sp.	1	S.
Nyssaceae ? (or Cornaceae ?)	Genus ? spp. 1 and 2.	2	S.
Myrtaceae	(*a*) *Palaeorhodomyrtus subangulata* (Bowerb.) n. gen.	7	S.
Myrtaceae ?	(*a*) *Hightea elliptica* Bowerb.	∞	S., H.B.
,,	(*c*) ,, *turgida* Bowerb.	73	S.
Cornaceae— (section Mastixioideae)	*Mastixia cantiensis* n. sp.	23+	S., H.B.
,, ,,	,, *grandis* n. sp.	2	S.
,, ,,	,, *parva* n. sp.	72	S., H.B.
,, ,,	*Langtonia bisulcata* n. gen. & sp.	76	S.
,, ,,	*Beckettia mastixioides* n. gen. & sp.	17	S.
,, ,,	*Lanfrancia subglobosa* n. gen. & sp.	17	S., H.B.
,, ,,	Genus ?	2	S.
Cornaceae (section Cornoideae)	(*a ?*) *Dunstania Ettingshauseni* (Gard.) n. gen.	5	S.
,, ,,	,, *multilocularis* n. sp.	183	S.
Epacridaceae	*Leucopogon quadrilocularis* n. sp.	7	S., H.B.
Myrsinaceae	*Ardisia ? eocenica* n. sp.	2	S.
Sapotaceae	*Sapoticarpum rotundatum* n. gen. & sp.	2	S.
,,	,, *latum* n. sp.	3	S.
,,	,, *dubium* n. sp.	2	S
,,	*Sapotispermum sheppeyense* n. gen. & sp.	7+	S.
,,	,, sp. 2.	1	S.
Symplocaceae	*Symplocos trilocularis* n. sp.	1	S.
,,	,, *quadrilocularis* n. sp.	1	S.
,,	,, *curvata* n. sp.	1	S.
Apocynaceae	*Ochrosoidea sheppeyensis* n. gen. & sp.	135	S., H.B.
,,	*Ochrosella ovalis* n. gen. & sp.	2	S.
Apocynaceae ? (or Asclepiadaceae ?)	*Jenkinsella apocynoides* n. gen. & sp.	6	H.B., St.
Boraginaceae	*Davisella ehretioides* n. gen. & sp.	2	H.
Solanaceae	*Cantisolanum daturoides* n. gen. & sp.	1	S.
Family Incertae Sedis.. ..	*Polycarpella caespitosa* n. gen. & sp.	1	S.
,, ,,	*Leyrida bilocularis* n. gen. & sp.	70	S.
,, ,,	,, *subglobularis* n. sp.	3	S.
,, ,,	*Neuroraphe obovatum* n. gen. & sp.	25	S.
,, ,,	*Lagenoidea trilocularis* n. gen. & sp.	75	S., Br.
,, ,,	,, *bilocularis* n. sp.	343	S.
,, ,,	*Lagenella alata* n. gen. & sp.	10	S., H.B.
,, ,,	(*a*) *Carpolithus subfusiformis* (Bowerb.).	3	S., H.B.
,, ,,	(*a*) ,, *tessellatus* (Bowerb.).	1	S.
,, ,,	,, *curtus* (Bowerb.).	3 (+1 ?)	S.
,, ,,	,, *gracilis* (Bowerb.).	2	S.
,, ,,	,, *crassus* (Bowerb.).	1	S.
,, ,,	,, *lentiformis* (Bowerb.).	2	S.

Family.	Genus and Species.	Approx. number of specimens.	Locality.
Family Incertae Sedis.. ..	*Carpolithus monasteriensis* n. sp.	1	S.
,, ,,	,, *thunbergioides* n. sp.	3	S., H.B.
,, ,,	,, *lignosus* n. sp.	1	S.
,, ,,	,, *ebenaceoides* n. sp.	1	S.
,, ,,	,, *quadripartitus* n. sp.	1	S.
,, ,,	,, *bignoniformis* n. sp.	1	S.
,, ,,	,, *ranunculoides* n. sp.	1	A.
,, ,,	,, *semencorrugatus* n. sp.	2	S.
,, ,,	,, *olacaceoides* n. sp.	1	S.
,, ,,	,, *Stonei* n. sp.	1	W.
,, ,,	,, *Bowerbanki* n. sp.	1	S.
,, ,,	,, *nervosus* n. sp.	11	S.
,, ,,	,, *scalariformis* n. sp.	5	S.
,, ,,	,, spp. 20–52.	—	S.; except sp. 35, A.
,, ,,	Bored wood, burrs, galls, concretions.	∞	S., etc.

The following we have not seen, but from the figures and descriptions we suggest that their affinities may be as indicated in the right-hand column below, and not as supposed by the original authors (left-hand column). Their nature is so doubtful that we have not incorporated them in the list above.

Sequoia Shrubsolei Gardner	*Petrophiloides* sp. ? possibly *P. Richardsonii* Bowerb.
Podocarpus argillae-londinensis Gardner ..	Lauraceae ? Genus ? sp. 3.
Piper sp. (Bowerbank, 1844)	Undetermined dicotyledonous wood.

2. Reasons for the Use of New Generic Names

It will be observed from the above list that although it has been possible to refer much the larger proportion of the species to living families, it has not been possible to refer them to living genera. There is more than one cause which has contributed to this result. It will suffice here to enumerate the causes and explain the general manner in which they have acted, leaving the way in which they have operated in individual species for discussion under the description of those species.

(i) *Extinction of Genera.*—In the first place there is the undoubted fact that many genera are extinct. We have been able to satisfy ourselves very definitely on this point in the case of some of the smaller families which have characteristic endocarps or seeds. We have in mind particularly the Menispermaceae, Burseraceae, and Cornaceae. In these families it has been possible to study a very complete range of living material, and the study has left no doubt but that most of the

London Clay genera referable to the families are extinct. This is indicated in more than one way: (*a*) The diagnostic characters are grouped in a manner not found in any of the living genera of a family; (*b*) definite numerical changes have occurred in important characters; (*c*) indefinite smaller changes, those of degree only, in many characters, have resulted in the living genera differing too considerably from the fossil species to permit of these being included within them. It will be appreciated that it may sometimes be extremely difficult to decide whether or not any particular species ought or ought not to be included in a living genus. We have attempted when such difficulties have arisen to give the evidence for and against inclusion. But it must always be a matter of individual judgment, when the evidence is clear, where the boundaries between inclusion and exclusion are to be drawn. We will now discuss in more detail these reasons for believing that a large proportion of the London Clay genera are extinct.

(*a*) **The changed grouping of diagnostic characters.**—One or two illustrations will suffice to explain what is meant by the changes which have occurred in the grouping of characters. The endocarps of the genus *Tricarpellites* Bowerb. (p. 271) closely resemble those of *Canarium* Linn., belonging to the family Burseraceae, in form and structure and in the mode of germination. Every coat in the endocarp of *Tricarpellites* has its counterpart in that of *Canarium*. The endocarps of *Canarium* are very thick and bony. Those of *Tricarpellites* were evidently the same. Consequently a special means is required to allow of germination, and the means adopted both in fossil and recent genera is identical. Both throw off valves from the dorsal face of each locule. Except that the valves of *Tricarpellites* are shorter than those of any species of *Canarium*, there is no difference between the endocarps of the fossil and recent genera. But with the structure and form of the endocarps the chief likeness between the fruits of the two genera ends. The seeds are different, because the seed organs of *Tricarpellites* do not resemble those of *Canarium* but those of some other genera of Burseraceae. In *Tricarpellites* the raphe is fairly long and the chalaza sub-triangular; whereas in *Canarium* the raphe is wanting and the chalaza is an arched, subtransverse band. But a raphe is found in some species of *Bursera* and *Protium;* and sub-triangular chalazas in *Bursera* and *Commiphora*. Therefore, whilst the endocarps of *Tricarpellites* resemble those of *Canarium*, the seeds do not. And contrariwise whilst the seeds resemble those of some other genera of Burseraceae, the endocarps do not. A similar rearrangement of characters is seen in regard to another fossil genus of Burseraceae, *Protocommiphora*. The nutlets of *Protocommiphora* resemble those of *Bursera* and *Commiphora*, whereas the chalaza of *Protocommiphora* is an arched band like the chalaza of *Protium* and *Canarium*, but unlike the heart-shaped or sub-triangular chalaza of *Bursera* and *Commiphora*. Other instances of similar recombinations of characters in living genera may be found in the Anacardiaceae. Thus the endocarps of *Pseudosclerocarya* have the form and number of locules of those of *Dracontomelon*, but not their ring of large paired holes beneath the equator of the endocarp; whilst, although otherwise less resembling *Sclerocarya*, they have its basal ring of small unpaired holes.

(*b*) **Numerical changes in important characters.**—Such a change is seen in the reduction in the number of locules which, with the lapse of time, has occurred in, or in relation to, certain genera. We first drew attention to this phenomenon in a previous work on the Bembridge Flora (Reid & Chandler, 1926, pp. 29, 63). It was there shown that *Sparganium* had undergone a reduction in the number of its locules with the lapse of time. *S. multiloculare* Reid & Chand. of the Bembridge Beds had 5-4-3-2-loculed forms; *S. ovale* Reid, from the Mio-Pliocene of Pont-de-Gail, had 2- and 1-loculed forms (1920, p. 58, pl. iii, figs. 1, 2). Forms of *S. ramosum* Huds. described by Hartz from Interglacial beds at Valby Bakke have 4-, 3-, or 2-locules (1909, p. 126, pl. v, figs. 14–16). The living genus is usually 1-loculed, but *S. eurycarpum* and *S. Greenei* are 2-loculed and *S. ramosum* Huds. may rarely have two locules. The chain of evidence is rather interrupted and irregular, but undoubtedly points to a reduction in the number of locules having occurred.

In the London Clay there is a considerable body of evidence pointing to reduction in the number of locules, although the evidence is sometimes complicated by other parallel changes which may have occurred. Reduction has been recognized in the sub-family Nyssoideae of the family Nyssaceae and in the sub-families Mastixioideae and Cornoideae of the family Cornaceae. At the present time *Nyssa* of the sub-family Nyssoideae is a 1-loculed fruit. In the London Clay the sub-family is represented by three species, which we have referred to two extinct genera. Of these two genera *Protonyssa*, with one species, has two locules; *Palaeonyssa*, with two species, may have either three or four locules. Both genera are so closely related to the living *Nyssa* in the general macroscopic and microscopic anatomy of their fruits and seeds, that it becomes a question whether or not they ought to be referred to the living genus. *Protonyssa*, in particular, differs only in the number of its locules, which suggests that it is merely a 2-loculed ancestor of *Nyssa*. *Palaeonyssa*, besides other slight differences, differs also in the shape of its germination valves. But this is a character which is very stable in the living genus. It seems impossible therefore to include *Palaeonyssa* in the living genus. The same character precludes it from union with *Protonyssa*. In view then of the occurrence of the two genera, we have given both new generic names. The probable relationship appears to be that *Protonyssa* with its two locules is the more immediately related type, whilst *Palaeonyssa* with its greater number of locules (not greater be it observed than in the living genus *Davidia* belonging to the same family), and the different form of its germination valve, is the more primitive type.

The Mastixioideae at the present day are represented by a single genus, *Mastixia*. In the London Clay the living genus itself is represented by three extinct species; but there are also three multilocular species which we have had to refer to three extinct genera under the names *Langtonia*, *Beckettia*, and *Lanfrancia*. In the Upper Eocene of Hordle there was also a multilocular form, *Eomastixia* Chandler, referred to the sub-family Mastixioideae (Chandler, 1926, p. 37, pl. vi, fig. 6). In their general form and the structure of their endocarps, in the mode of germination by throwing off longitudinally infolded valves, and in the arrangement of the seed organs and microscopic structure of the seeds, all these extinct genera show a very close relationship with *Mastixia*; but all are multilocular. *Eomastixia* and *Langtonia* have two locules, *Beckettia* has three locules, whilst *Lanfrancia* has three or four locules. There are certain differences in the form of the valves and disposition of the parenchyma in the endocarps which make the relationship to *Mastixia* less marked than is that of *Protonyssa* and *Palaeonyssa* to *Nyssa*. Nevertheless the relationship is very close and must indicate a reduction in the number of locules with the lapse of time.

Dunstania, referred to the section Cornoideae of the Cornaceae, shows evidence of reduction in the number of locules to an even greater degree. Related, as evidenced by the structure of its endocarps and seeds, to the living genus *Cornus*, it has from three to six locules, whereas *Cornus* has but two. Nevertheless the relationship between fossil and living, although evident, is not so close as in the other cases cited above, being complicated by other changes such as we will consider in the next section.

(*c*) **Changes of degree in many characters.**—We have already alluded to the occurrence of small changes in the preceding section in the case of the valve of *Palaeonyssa* and of similar changes in the fossil genera of the Cornaceae. But in all these the importance of the small changes was considerably masked by the more striking change seen in the number of locules. We must now consider cases in which changes of degree, alone, in certain characters, seem to demand the institution of new genera. In *Tinomiscoidea scaphiformis* the endocarps bear a general resemblance to those of several genera in the section Fibraureae of the family Menispermaceae, and especially to the endocarps of *Tinomiscium*. Yet they show differences in detail from those of any of the living species of *Tinomiscium* which, in our opinion, must exclude them from the genus. The living endocarps are all larger—this in itself is not of much importance—but in all living species the concavity on the ventral face of the endocarp is much smaller than it is in the fossil; also the lateral margins between the dorsal and ventral faces are rounded, not faceted as in the fossil. There is, therefore, conformity among the living species in respect of certain characters which is wanting in the fossil. We have consequently thought it necessary to institute a new genus.

Sometimes the change, although in itself apparently slight, may be associated with such an important organ that, again, it has seemed necessary to institute a new genus. We have in mind as an example the transverse folding upon themselves of the cotyledons in *Palaeallophylus*, one of the Sapindaceae. The folding of the cotyledons most resembles that seen in the seeds of *Allophylus*, but the rotation of the transverse folds in relation to the hypocotyl is greater in *Palaeallophylus* than in any species of *Allophylus*. Consequently it was impossible to place the fossil in the living genus.

We thus see that changes of one kind or another point to a great extinction of genera between the period of the London Clay and the present day. We have reached the conclusion that the evidence definitely indicates extinct genera in the following families: Araucarineae, Palmae, Juglandaceae, Nymphaeaceae, Menispermaceae, Lauraceae, Hamamelidaceae, Linaceae, Burseraceae, Anacardiaceae, Celastraceae, Icacinaceae, Sapindaceae, Vitaceae, Tiliaceae, Sterculiaceae, Bixaceae, Lythraceae, Onagraceae, Nyssaceae, Myrtaceae, Cornaceae, Apocynaceae and Boraginaceae. We do not therefore make any very great assumption if we postulate their occurrence in other families. Indeed, the incidence of extinct genera in such small families as the Menispermaceae, Burseraceae, and Cornaceae, which we have been able to study very completely, suggests that the proportion of extinct to living genera in the London Clay was probably very high—possibly as much as 75 per cent.

(ii) *Inadequate Knowledge of Living or Fossil Material, or of both.*—The occurrence of extinct genera is not the only cause that has made it impossible in many cases to refer the fossil members of a family to living genera. In a very considerable degree the failure is due to our insufficient knowledge either of the fossils themselves or of the living species of the family to which the fossils belong. Failures of this kind to make generic determinations occur most commonly in large families. In several of these the ordinal characters are well marked, whilst the generic and specific characters are much less so, especially the more superficial ones. For example, the seeds of the Anonaceae are very readily distinguishable by their bisymmetry, emphasized by a fibrous lateral girdle formed of the raphe and chalaza, and by the remarkable ruminations of the testa and albumen. Hence the ordinal characters are very clear and can easily be distinguished in the fossil state. But whilst ruminate testas and bisymmetric form pertain to the whole family, the type of rumination and the form of seed may vary considerably. The difficulty of generic determination arises because similar types of rumination and similar form may occur in more than one genus. For instance, similar forms and types of rumination occur in *Uvaria*, *Ellipeia*, *Dasymaschalon*, and *Anona*. On the other hand, very different types of rumination may occur in the same genus; for example, in *Polyalthia* and *Guatteria*. Consequently to assign a miscellaneous collection of living seeds of Anonaceae to their respective genera might require prolonged microscopical study, if, as is the case with fossil seeds, there were no colour to help. It follows that in order to discriminate between fossil genera and relate them to living ones, it would first be necessary to make microscopic studies of all the commoner living forms, as well as of the fossils. Such work would be impossible in dealing with a large flora like that of the London Clay. Moreover, when the distortion of specimens, and the degree of extinction are taken into account, it is very doubtful whether the work, when done, would lead to any dependable results. Therefore we have not attempted any exhaustive microscopic study of these large families as a whole, but have confined our study to the more peculiar forms. The more exhaustive research is better suited for monographs on families and genera than for a general research such as we are now undertaking.

The families to which these remarks especially apply in the present work are the Anonaceae, Sapindaceae, Lauraceae, and Euphorbiaceae. In regard to the Anonaceae the difficulties have already been explained. In the Sapindaceae the seeds, which are more frequently preserved than the fruit, in the London Clay, are chiefly to be distinguished by the form and arrangement of the embryo, features which it is not always possible to study in living material, and which are but rarely preserved in the fossils with sufficient clearness to be used as generic characters. In the Lauraceae the fruits and seeds together afford most characteristic ordinal evidence ; but for more definite determination there is this drawback—the pericarp and testa are so alike in several living genera that it is only by the most careful microscopic measurements of successive layers of cells that one could hope to discriminate between these genera, were there no colour to help. Such measurements of cells in all the living forms was more than we could undertake in the present work, and there was the further consideration that even when made the measurements might be of doubtful value for determining the fossils, many of which are probably extinct. Nevertheless, we have measured and recorded the measurements of the cells in the fossils, because we found them sometimes to be of value in differentiating the fossil species ; also, that they might be available for future workers. The case is much the same with the Euphorbiaceae, a very large family in which, whilst the ordinal characters are clear, the generic characters of both fruits and seeds are very much less so. We could therefore feel no confidence that it was possible to relate the fossil species with any degree of reliability when several living genera might be in question, and the fossil genus itself might be extinct. This want of information has generally pointed to the desirability of using form names, either with or without specific names according to the degree of characterization of the species, whilst occasionally it has seemed desirable to create new generic names.

The occurrence of so many extinct genera must naturally raise the question of extinct families. We have more than once been puzzled whether or not to include species in living families. The same difficulty arises in regard to the family characters as that just discussed in reference to the generic characters. The characters may be all there, but some of them in a very considerably modified form ; or, again, one or two may not be there, although all the other characters would point to a certain family. Are such species to be regarded as extinct members of the family, or may they rather represent an extinct but allied family ? We do not see how to reach any satisfactory decision on this point ; at least not from the study of one fossil flora only. Consequently, when the evidence seemed to warrant it, we have placed these species doubtfully within the living families which seem to be allied. Such a step, whilst it must be clearly understood not to indicate definite ordinal relationship, has the merit of marking a possible alliance, and of saving the species from being buried in the limbo of that all-embracing fossil genus, *Carpolithus*. Nevertheless, we wish to make it quite clear that in any deductions we may make in the course of this work upon the character and implications of the flora of the London Clay, these doubtfully related genera and species are ignored.

In speaking of doubtfully determined genera we would take this opportunity to plead for a stricter use of the names of living genera than often finds place in palaeobotany. We could give many examples of careless use, but will confine ourselves to one. Most authors on Tertiary palaeobotany have had occasion at one time or another to describe species which are variously assigned to the living genera *Myrica*, *Comptonia*, *Banksia*, or *Dryandra*. Nearly all are agreed as to the difficulty of deciding which is the true ascription or, indeed, if any of them are right at all. Yet in but very few instances have we met with any indication in the naming and listing of the genera that this doubt exists. This is merely one instance. There are endless others. There are instances in which writers have used the names of living genera as form names for species. These should properly be referred to the appropriate families under new form names. Such usages are regrettable because they imply a certainty which, often on the author's own showing, is not there. Thus they invalidate the work. It is undoubtedly desirable and necessary to name well-defined fossil genera of which the relationship is questionable, but it can be done without blurring incomplete evidence and confusing the boundaries of living generic names. Having entered this plea for caution, we would enter a complementary one for courage. If a species can definitely be proved to belong to a living genus then let the name of the genus be used, and discard such half-hearted names as *Nipadites*, which imply a lack of evidence that is not warranted by facts. We could wish for an altogether stricter usage of names in Tertiary palaeobotany. Let the degree of certainty or uncertainty be reflected in the published lists and not be found merely in the discussion of species. Uncertainty of determination concealed beneath a certainty of naming destroys confidence and renders work nugatory.

But to return to the question of extinct genera. Reviewing the list of genera and species given on pp. 34–40, we find that the number of genera about which we possess fairly definite evidence, whether they are living or extinct, is about ninety. Of this number twenty-five are living and about sixty-five extinct. That is to say we have fairly definite knowledge that over two-thirds of the determined flora are extinct. In actuality the proportion of extinct genera must have been very much higher as is indicated by the numbers of species we have been unable to place definitely, not always from a lack of knowledge of the structure of the fossils, but because we could find no living material comparable. It is to be noted that all species, without any exception, are extinct. It is manifest that great changes have occurred since the period of the London Clay within many living families. Whether these changes have been in the line of direct descent, or were changes in collateral relationship—that is whether the London Clay forms were ancestral to the living or may represent collateral branches—we cannot tell at present, although with the accumulation of fossil evidence it should perhaps be discoverable. When, as in the Nyssaceae and Cornaceae, one of the chief generic distinctions lies in the reduction in the number of locules with the passage of time, it seems probable that some at least among the London Clay fossils represent ancestral forms.

3. Distribution of Living Representatives

(i) *Families.*—The next fact to remark is this, that all the families, without exception, which we definitely know to be represented in the flora, enter the tropics. Five of them are entirely tropical, namely, Nipaceae, Burseraceae, Icacinaceae, Bixaceae, and Sapotaceae, making over 11 per cent. of the whole of these known families. Fourteen families are almost exclusively tropical, namely, Palmae, Olacaceae, Menispermaceae, Anonaceae, Lauraceae, Meliaceae, Anacardiaceae, Sapindaceae, Sabiaceae, Elaeocarpaceae, Sterculiaceae, Dilleniaceae, Myrsinaceae, and Apocynaceae, making 32 per cent. Twenty-one are equally tropical and extra-tropical, namely, Araucarineae, Cupressineae, Juglandaceae, Nymphaeaceae, Magnoliaceae, Hamamelidaceae, Leguminosae, Linaceae, Rutaceae, Euphorbiaceae, Celastraceae, Vitaceae, Tiliaceae, Lythraceae, Nyssaceae, Myrtaceae, Cornaceae, Epacridaceae, Symplocaceae, Boraginaceae, and Solanaceae, making 46 per cent. And five, namely, Taxaceae, Trochodendraceae, Saxifragaceae, Haloragaceae, and Onagraceae, making 11 per cent., although they enter the tropics, are chiefly temperate.

It is instructive to compare this distribution with that of all the families which enter the tropics in the present day. We have taken the distribution from Engler's "Pflanzenfamilien" (1887) and Willis's "Dictionary of Flowering Plants and Ferns" (1919). It is evident that the two sets of figures are fairly comparable ; a fact which at once suggests that the London Clay flora was tropical.

	Per cent. exclusively tropical.	Per cent. mainly tropical.	Per cent. equally tropical and extra-tropical.	Per cent. mainly extra-tropical.
Living tropical families ..	15	32·5	32·5	20
London Clay families ..	11	32	46	11

The question of tropical relationship is, however, so important that it will not do to rest content with *prima facie* evidence. It must be tested by every available means.

(ii) *Genera.*—First let us consider the evidence of the most nearly related living genera. These are represented in the London Clay sometimes by members of the living genera themselves, but more often by members of closely allied extinct genera. In either case they constitute the living representative genera, and under this name we have tabulated them. The number of London Clay genera whose living representatives we have been able to trace is seventy. We give them in the following table. The table was compiled in the first instance from Engler's "Pflanzenfamilien" and Willis's "Dictionary," and was later checked throughout by reference to the "Index Kewensis."

DISTRIBUTION AND HABITAT OF THOSE LIVING GENERA TO WHICH THE LONDON CLAY GENERA ARE MOST NEARLY ALLIED

Fossil Genus.	Nearest living genus.	Distribution of nearest living genera.																							Habitat.		
		North Europe.	North Asia.	North North-America.	North-west Europe.	South Europe and Mediterranean.	Caucasus.	Western Asia.	Himalayas.	Japan and North China.	South China and Burma.	India and Ceylon.	Further India.	Malay Peninsula.	Malay Islands.	Australia, New Zealand, New Caledonia.	Tropical Africa.	Eastern U.S.A.	Western U.S.A.	Central America and West Indies.	South America.	Madeira, Canaries, etc.	Madagascar and Mascarene Islands.	Philippines.	Lowland tropical only.	Extra-tropical only (in alt. or lat.).	Both lowland trop. and extra-trop.
1. *Araucarites.*	*Araucaria.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	+	—	—	—	—	—	+
2. *Cupressinites.*	*Widdringtonia* and *Tetraclinis.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+	—	—	+	—
3. *Cephalotaxus.*	*Cephalotaxus.*	—	—	—	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	—	—	—	—	—	—	+	—
4. *Oncosperma ?*	*Oncosperma.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—	—	—	—	—	—	—	—	—	+	—	—
5. *Caryotispermum.*	*Caryota.*	—	—	—	—	—	—	—	+	—	—	+	+	+	+	+	—	—	—	—	—	—	—	+	+	—	—
6. *Sabal.*	*Sabal.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	+	—	—	—	—	—	+
7. *Serenoa.*	*Serenoa.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	+
8. *Livistona ?*	*Livistona.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	+
9. *Nipa.*	*Nipa.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—	—	—	—	—	—	—	—	—	+	—	—
10. *Petrophiloides.*	*Petrophiloides* (syn. *Platycarya*).	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—
11. *Erythropalum.*	*Erythropalum.*	—	—	—	—	—	—	—	+	—	+	+	+	+	+	—	—	—	—	—	—	—	—	+	+	—	—
12. *Olax.*	*Olax.*	—	—	—	—	—	—	—	+	—	—	+	+	+	+	+	+	—	—	—	—	—	+	—	—	—	+
13. *Protobarclaya.*	*Barclaya.*	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—	+	—	—
14. *Trochodendron ?*	*Trochodendron.*	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—
15. *Bowerbankella.*	*Tiliacora.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—	+	—	—	—	—	—	—	—	+	—	—
16. *Tinomiscoidea.*	*Tinomiscium.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	+	+	—	—
17. *Microtinomiscium.*	*Tinomiscium.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	+	+	—	—
18. *Tinospora.*	*Tinospora.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	—	+	+	—	—
19. *Eohypserpa.*	*Hypserpa.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	—	+	+	—	—
20. *Magnolia.*	*Magnolia.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	+	—	+	—	—	—	—	—	—	+
21. *Endiandra.*	*Endiandra.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	+	—	—
22. *Cinnamomum.*	*Cinnamomum.*	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	+
23. *Litsea.*	*Litsea.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	+
24. *Beilschmiedia.*	*Beilschmiedia.*	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	—	—	+	+	—	—	—	—	—	+
25. *Protoravensara.*	*Ravensara.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	—	—
26. *Protaltingia.*	*Altingia.*	—	—	—	—	—	—	—	—	+	+	—	+	+	+	—	—	—	—	—	—	—	—	—	—	—	+
27. *Wetherellia.*	*Hugonia.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	—	—	—	—	—	—	—	+	—	—
28. *Clausenispermum.*	*Clausena.*	—	—	—	—	—	—	—	+	—	+	+	+	+	+	+	+	—	—	—	—	—	—	—	+	—	—
29. *Tricarpellites.*	*Canarium* and *Bursera.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	+	+	—	—	+	+	—	—

30.	*Protocommiphora.*	*Commiphora.*	—	—	—	—	—	—	—	+	—	—	+	+	+	+	—	+	—	—	—	—	—	+	—	—	—	+
31.	*Toona.*	*Toona.*	—	—	—	—	—	—	—	+	—	—	+	+	+	+	+	—	—	—	—	—	—	—	+	—	—	+
32.	*Euphorbiospermum.*	*Cleidion.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	+	—	—	+	+	—	—	—	+	—	—
33.	*Dracontomelon.*	*Dracontomelon.*	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	+	+	—	—
34.	*Sclerocarya.*	*Sclerocarya.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+	—	+	—	—
35.	*Pseudosclerocarya.*	*Sclerocarya.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+	—	+	—	—
36.	*Spondias.*	*Spondias.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—	+	—	—	+	+	—	+	+	+	—	—
37.	*Spondicarya.*	*Spondias.*	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—	+	—	—	+	+	—	+	+	+	—	—
38.	*Odina.*	*Odina.*	—	—	—	—	—	—	—	—	—	+	+	+	—	+	—	+	—	—	—	—	—	+	—	+	—	—
39.	*Cathispermum.*	*Catha.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	+
40.	*Iodes.*	*Iodes.*	—	—	—	—	—	—	—	—	+	+	+	+	+	+	—	—	—	—	—	—	—	+	+	+	—	—
41.	*Palaeophytocrene.*	*Phytocrene* and *Chlamidocarya.*	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—	+	—	—	—	—	—	—	—	+	—	—
42.	*Stizocarya.*	*Phytocrene.*	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—	+	—	—
43.	*Palaeallophylus.*	*Allophylus.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	+	—	—	—	+	—	+	+	+	—	—
44.	*Palaealectryon.*	*Alectryon.*	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	+
45.	*Meliosma.*	*Meliosma.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	+	+	—	—	—	—	—	+
46.	*Vitis.*	*Vitis.*	—	—	—	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+	+	—	—	+
47.	*Tetrastigma.*	*Tetrastigma.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	+	—	—	—	—	—	—	+	—	—	+
48.	*Ampelopsis.*	*Ampelopsis.*	—	—	—	—	—	—	—	+	+	+	+	—	—	—	—	—	+	+	—	—	—	—	—	—	—	+
49.	*Echinocarpus.*	*Echinocarpus.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	+
50.	*Cantitilia.*	*Tilia.*	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	—	+	—	+	—	—	—	—	—	+	—
51.	*Sphinxia.*	*Dombeya* and *Trochetia.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+	—	+	—	—
52.	*Tetracera.*	*Tetracera.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	+	+	+	—	—
53.	*Oncoba.*	*Oncoba.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	+	—	+	—	+	—	—
54.	*Oncobella.*	*Oncoba.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	+	—	+	—	+	—	—
55.	*Minsterocarpum.*	*Lagerstroemia.*	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	—	—	—	—	—	+	+	+	—	—
56.	*Palaeeucharidium.*	*Eucharidium.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	+	—
57.	*Protonyssa.*	*Nyssa.*	—	—	—	—	—	—	—	+	+	+	—	+	—	+	—	—	+	—	—	—	—	—	—	—	—	+
58.	*Palaeonyssa.*	*Nyssa.*	—	—	—	—	—	—	—	+	+	+	—	+	—	+	—	—	+	—	—	—	—	—	—	—	—	+
59.	*Palaeorhodomyrtus.*	*Rhodomyrtus.*	—	—	—	—	—	—	—	—	+	+	+	—	+	+	+	—	—	—	—	—	—	—	+	—	—	+
60.	*Mastixia.*	*Mastixia.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	+
61.	*Lanfrancia.*	*Mastixia.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	+
62.	*Langtonia.*	*Mastixia.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	+
63.	*Beckettia.*	*Mastixia.*	—	—	—	—	—	—	—	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—	—	—	+
64.	*Dunstania.*	*Cornus.*	+	+	+	+	+	+	+	+	+	+	—	—	—	—	—	+	+	+	+	—	—	—	—	—	+	—
65.	*Ardisia ?*	*Ardisia.*	—	—	—	—	—	—	—	+	+	+	+	+	+	+	+	—	+	—	+	+	—	+	—	—	—	+
66.	*Leucopogon.*	*Leucopogon.*	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—	+
67.	*Symplocos.*	*Symplocos.*	—	—	—	—	—	—	—	—	+	+	+	+	+	+	+	—	+	+	+	+	—	—	—	—	—	+
68.	*Ochrosoidea.*	*Ochrosia.*	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—	—	—	—	—	—	+	—	+	—	—
69.	*Ochrosella.*	*Ochrosia.*	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—	—	—	—	—	—	+	—	+	—	—
70.	*Davisella.*	*Ehretia.*	—	—	—	—	—	—	—	+	+	+	+	+	—	—	+	+	—	—	+	+	—	+	+	—	+	—
		Number of genera in each region.	1	1	1	2	3	3	3	22	25	37	43	46	47	51	28	27	11	5	14	15	0	21	19	33	8	29
		Nearest integral percentage.	1	1	1	2	4	4	4	31	36	53	61	66	67	73	40	39	16	7	20	21	0	30	27	47	11·5	41·5

The better to demonstrate the proportional distribution of representative genera we have reduced the numbers for the different regions to percentages. It will be seen that the closest phytogeographical relationship is with the very heart of the East Asian tropics, namely, with the Malay Islands, where 73 per cent. of the genera are found at the present day. This relationship is followed by the Malay Peninsula with 67 per cent., Further India with 66 per cent., and India and Ceylon with 61 per cent. In order still more clearly to show the range of distribution we have plotted all the percentages diagrammatically (see the Diagrams of Distribution, p. 54). The diagram shows very strikingly the almost entire absence of phytogeographical relationship with Europe and western Asia. It is not until the tropical Himalayas are reached that representatives of the London Clay are found in any number. From the Himalayas south-eastward and southward the generic relationship increases, culminating, as we have seen, in the Malay Islands.

It is necessary, however, if we are to form an adequate idea of the affinities of the flora, to inquire into the habitat of the representative genera. Are they lowland or montane? Are they exclusively tropical, or may they also be extra-tropical? The chief sources of our information on this subject are "The Flora of the Malay Peninsula" (Ridley), "An Enumeration of Philippine Flowering Plants" (Merrill), "The Forests of India" (Stebbing), the sheets in Kew Herbarium, and much valuable verbal information from Mr. H. N. Ridley and Mr. I. H. Burkill, who were, in succession, Directors of the Botanical Gardens at Singapore. The facts concerning the habitat of *Sabal* and *Serenoa* are taken from "The Distribution of Vegetation in the United States as related to Climatic Conditions" (Livingston and Shreve). The facts of habitat are tabulated alongside of the tables of distribution. The tables show that out of the seventy genera thirty-three, or 47 per cent., of the living related genera are lowland tropical forms, that is exclusively tropical in their distribution; twenty-nine, or 41·5 per cent., are lowland tropical and, as well, either montane in the tropics or extra-tropical in latitudinal distribution; whilst eight, or 11·5 per cent., are either exclusively montane in the tropics, or extra-tropical. It is to be noted that *Nipa*, which is exclusively tropical, grows only at the sea-level and requires brackish water; *Oncosperma* also is a strand genus in the Malayan tropics; whilst *Allophylus* and *Ehretia* have species which form part of the strand flora of the tropics, growing at the back of the mangrove swamps. The evidence of the genera therefore, like that of the families, points to the London Clay being a tropical flora.

4. Comparison between London Clay and Later Tertiary Floras in regard to the Changes which have Occurred

From this study of the London Clay flora as an isolated unit, we now pass to a comparative study in relation to other Tertiary floras. For this purpose we have listed the distribution of genera from six other Tertiary floras, studied by ourselves and of which the age is fairly certain, in the same way as has been done for the

London Clay. Only those genera are listed the relationship of which we regard as securely established. The percentage distributions have been calculated and the results plotted in the Diagrams of Distribution (p. 54). Could we have made comparison with species instead of genera the result would have been more valuable, but the changes which have occurred in fruits and seeds since the time of the earlier floras make it increasingly difficult, as we go back in time, to trace the nearest living species; more especially when, as in the London Clay, the changes have been so great as frequently to forbid inclusion in living genera.

Lists of Fossil Genera of Known Relationship on whose Distribution in the Present the Diagrams of Distribution are Based

Cromer

Reid, C. & E. M., 1908

Pinus	*Alnus*	*Spiraea*	*Chaerophyllum*	*Solanum*
Picea	*Fagus*	*Pyrus*	*Torilis*	*Verbascum*
Taxus	*Quercus*	*Mespilus*	*Conium*	*Limosella*
Sparganium	*Ulmus*	*Rubus*	*Apium*	*Veronica*
Potamogeton	*Urtica*	*Potentilla*	*Cicuta*	*Littorella*
Zannichellia	*Rumex*	*Alchemilla*	*Oenanthe*	*Galium*
Najas	*Polygonum*	*Prunus*	*Aethusa*	*Viburnum*
Sagittaria	*Chenopodium*	*Euphorbia*	*Pastinaca*	*Valerianella*
Alisma	*Atriplex*	*Corema*	*Heracleum*	*Valeriana*
Stratiotes	*Stellaria*	*Acer*	*Cornus*	*Eupatorium*
Eriophorum	*Arenaria*	*Rhamnus*	*Menyanthes*	*Bidens*
Scirpus	*Nuphar*	*Hypericum*	*Ajuga*	*Tussilago*
Heleocharis	*Nymphaea*	*Elatine*	*Prunella*	*Arctium*
Carex	*Ceratophyllum*	*Viola*	*Ballota*	*Carduus*
Salix	*Caltha*	*Trapa*	*Stachys*	*Centaurea*
Carpinus	*Ranunculus*	*Circaea*	*Calamintha*	*Picris*
Corylus	*Thalictrum*	*Myriophyllum*	*Lycopus*	*Crepis*
Betula	*Hypecoum*	*Hippuris*	*Mentha*	*Leontodon*

Tegelen

Reid, C. & E. M., 1907, 1908*a*, 1910, 1914, 1915; for *Decodon*, Reid, E. M., 1927; Nikitin, 1929; for *Eucommia*, Baas, 1932, pp. 336, 337

Pinus	*Alnus*	*Thalictrum*	*Actinidia*	*Stachys*
Juniperus	*Urtica*	*Menispermum*	*Hypericum*	*Melissa*
Sparganium	*Rumex*	*Magnolia*	*Decodon*	*Calamintha*
Potamogeton	*Polygonum*	*Eucommia*	*Viola*	*Origanum*
Najas	*Chenopodium*	*Mespilus*	*Trapa*	*Thymus*
Sagittaria	*Atriplex*	*Rubus*	*Myriophyllum*	*Lycopus*
Alisma	*Stellaria*	*Potentilla*	*Hippomarathrum*	*Mentha*
Stratiotes	*Lychnis*	*Prunus*	*Petroselinum*	*Physalis*
Scirpus	*Euryale*	*Phellodendron*	*Cicuta*	*Solanum*
Heleocharis	*Ceratophyllum*	*Corema*	*Laserpitium*	*Veronica*
Dulichium	*Aquilegia*	*Staphylea*	*Verbena*	*Valeriana*
Carex	*Clematis*	*Acer*	*Teucrium*	*Bidens*
Pterocarya	*Ranunculus*	*Vitis*	*Prunella*	*Carduus*
Carpinus				

Reuver

Reid, C. & E. M., 1915; for *Pseudolarix*, Florschütz, 1925; for *Eucommia* and *Decodon*, see p. 51

Pseudolarix	*Betula*	*Liriodendron*	*Aesculus*	*Cornus*
Picea	*Alnus*	*Menispermum*	*Meliosma*	*Helwingia*
Larix	*Fagus*	*Cinnamomum*	*Karwinskia*	*Maesa*
Pinus	*Quercus*	*Bucklandia*	*Rhamnus*	*Ardisia*
Sequoia	*Zelkova*	*Liquidambar*	*Vitis*	*Diospyros*
Sparganium	*Urtica*	*Corylopsis*	*Actinidia*	*Styrax*
Potamogeton	*Hakea*	*Eucommia*	*Stuartia*	*Jasminum*
Najas	*Pyrularia*	*Cotoneaster*	*Hypericum*	*Ajuga*
Sagittaria	*Polygonum*	*Pyrus*	*Decodon*	*Sideritis*
Alisma	*Nelumbium*	*Mespilus*	*Viola*	*Lycopus*
Scirpus	*Brasenia*	*Rubus*	*Nyssa*	*Hancea*
Cladium	*Nuphar*	*Prunus*	*Trapa*	*Melissa*
Dulichium	*Euryale*	*Biebersteinia*	*Circaea*	*Galium*
Carex	*Ceratophyllum*	*Orixa*	*Proserpinaca*	*Sambucus*
Epipremnum	*Anemone*	*Phellodendron*	*Myriophyllum*	*Eupatorium*
Pterocarya	*Clematis*	*Pistacia*	*Hippuris*	*Helichrysum*
Carya	*Ranunculus*	*Ilex*	*Aralia*	*Senecio*
Carpinus	*Thalictrum*	*Staphylea*	*Petroselinum*	*Carduus*
Corylus	*Magnolia*	*Acer*	*Cicuta*	*Crepis*

Pont-de-Gail

Reid, E. M., 1920, 1924; for *Decodon*, see p. 51

Sparganium	*Alnus*	*Crataegus*	*Hypericum*	*Clerodendron*
Potamogeton	*Pilea*	*Pyrus*	*Decodon*	*Ehretia*
Najas	*Rumex*	*Rubus*	*Calothamnus*	*Lithospermum*
Alisma	*Polygonum*	*Prunus*	*Myriophyllum*	*Amethystia*
Stratiotes	*Fagopyrum*	*Phellodendron*	*Acanthopanax*	*Lycopus*
Cyperus	*Ranunculus*	*Buchanania*	*Aralia*	*Solanum*
Carex	*Menispermum*	*Ilex*	*Oenanthe*	*Hyoscyamus*
Epipremnum	*Magnolia*	*Meliosma*	*Cornus*	*Sambucus*
Carpinus	*Cleomella*	*Vitis*	*Primula*	*Trichosanthes*
Betula	*Polanisia*	*Actinidia*	*Symplocos*	

Bembridge

Reid & Chandler, 1926

Libocedrus	*Ottelia*	*Engelhardtia*	*Ranunculus*	*Phyllanthera*
Cupressus	*Stratiotes*	*Carpinus*	*Cinnamomum*	*Melissa*
Araucarites	*Carex*	*Fagus*	*Neolitsea*	*Acanthus*
Typha	*Sabal*	*Quercus*	*Papaver*	*Catalpa*
Sparganium	*Palaeothrinax*	*Ficus*	*Aldrovanda*	*Incarvillea*
Potamogeton	*Epipremnum*	*Brasenia*	*Zanthoxylon*	*Abelia*
Najas	*Costus*	*Clematis*	*Zizyphus*	*Dipelta*

Hordle

Chandler, 1925–1926; for *Aldrovanda* Reid & Chandler, 1926, pp. 113, 114

Pinus	*Chlorophora*	*Corydalis*	*Iodes*	*Mastixicarpum*
Sequoia	*Broussonetia*	*Aldrovanda*	*Tetrastigma*	*Eomastixia*
Potamogeton	*Orites*	*Liquidambar*	*Vitis*	*Diospyros*
Stratiotes	*Atriplex*	*Rubus*	*Parthenocissus*	*Symplocos*
Cladium	*Brasenia*	*Zanthoxylon*	*Ampelopsis*	*Styrax*
Nipa	*Menispermum*	*Phellodendron*	*Actinidia*	*Omphalodes*
Campylospermum	*Cinnamomum*	*Natsiatum*	*Gordonia*	*Sambucus*

Before discussing detailed questions of phytogeographical relationships in connexion with the diagrams, there are two points which suggest themselves for comment. Firstly, there is the change which has taken place in the woody character of the successive floras since the period of the London Clay. Secondly, there is the change that has taken place in the proportion of wide-ranging genera.

(i) *Changes in the Woody Character of the Floras.*—So far as we have been able to determine the London Clay flora, the generic alliances indicate that with the exception of *Protobarclaya* (a water plant) and *Palaeeucharidium* the flora was composed of woody plants. The traced generic relationships therefore indicate that about 97 per cent. of the plants must have been woody. On a similar basis the proportion in the Hordle flora was 85 per cent. ; in the Bembridge, 57 per cent. ; in the Pont-de-Gail, 51 per cent. ; in the Reuverian, 57 per cent. ; in the Teglian, 28 per cent. ; and in the Cromerian, 22 per cent. For comparison it may be noted that in the living flora of Britain it is 17 per cent. Hence it appears that the flora of Western Europe underwent a profound transformation in regard to its ligneous character between the period of the London Clay and the Cromerian ; and the change was progressive, save possibly for a tendency to be stationary and slightly irregular in the middle period between the Bembridge flora and the Reuverian. But in regard to the lesser proportion of woody plants in the Pont-de-Gail flora as compared with those of Bembridge and Reuver, it must be remembered that the Pont-de-Gail flora belonged to an inland volcanic district, whereas the two other floras were derived from low ground flanking ancient estuaries. This slight irregularity apart, it is quite clear that in the period intervening between the London Clay and the end of the Pliocene, the flora of west Europe was transformed from one of predominantly ligneous type to one predominantly herbaceous, and that the change was progressive.

There are two causes which might have operated to produce the change and it is highly probable that both were effective. In the first place it is very generally accepted among botanists that the evolution of trees largely preceded that of herbs (Willis, 1922, p. 46 ; Sinnott & Bailey, 1914, p. 547). If this order of development be the true one, it naturally follows that the oldest floras would be the most ligneous, and that the proportion of ligneous plants would diminish with the age of successive floras. There is, however, another cause which probably had an equal share in determining the character of the London Clay flora and of those which succeeded it. The distribution of the living representative genera of the London Clay flora shows that it was tropical in its association. Now tropical floras are characterized by the preponderance of woody forms, and in passing from the tropics to the cold regions the proportion of woody plants diminishes. Therefore, since the diagrams of distribution indicate a cooling climate during the Tertiary period from the Middle Eocene onwards, it is probable that much of the change in ligneous character was due to change of climate. In any case the ligneous character of the London Clay flora is in keeping with the tropical character expressed by its phytogeographical relationships.

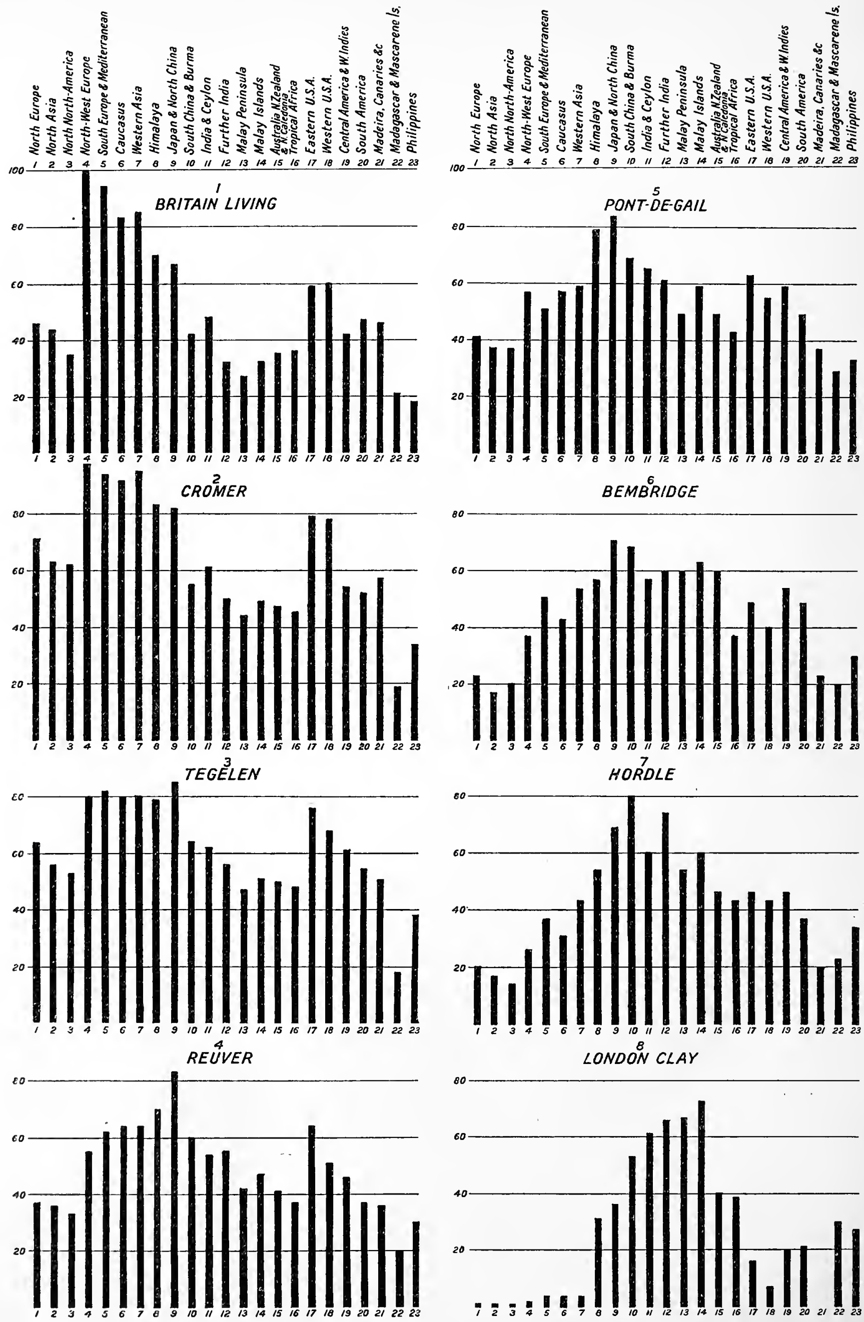
TABLE AND DIAGRAMS SHOWING

THE PERCENTAGE DISTRIBUTION OF GENERA

IN CERTAIN FOSSIL FLORAS OF WEST EUROPE AND IN THE LIVING BRITISH FLORA

1. Britain	46	44	35	100	94	83	85	70	67	42	48	32	27	32	35	36	59	60	42	47	46	21	18
2. Cromer	71	63	62	98	94	92	95	83	82	55	62	50	44	49	47	51	79	78	54	52	57	19	34
3. Tegelen	64	56	53	80	82	80	80	79	85	64	62	56	47	51	50	48	76	68	61	55	51	18	38
4. Reuver	37	36	33	55	62	64	64	70	83	60	54	55	42	47	39	35	64	51	46	37	36	20	30

41	37	37	57	51	57	59	79	84	69	65	61	49	59	49	43	63	55	59	49	37	29	35	Pont-de-Gail 5.
23	17	20	37	51	43	54	57	71	69	57	60	60	63	60	37	49	40	54	49	23	20	37	Bembridge 6.
20	17	14	26	37	31	43	54	71	80	60	74	54	60	46	43	46	43	46	37	20	23	34	Hordle 7.
1	1	1	2	4	4	4	31	36	53	61	66	67	73	40	39	16	7	20	21	0	30	27	London Clay 8.



(ii) *Changes in the Proportion of Wide-ranging Genera.*—Even in a cursory glance at the Diagrams of Distribution the eye is at once arrested by the difference in character between the diagrams for the London Clay and for those of the floras that come after it. In the London Clay diagram the distribution of living representative genera is of a markedly restricted type, being associated chiefly with the eastern part of the Old World (including Australia) to the comparative exclusion of the New, and in particular is associated with Indo-Malaya. It is a distribution which demands explanation, and must hold a prominent place when we come to consider the nature of the London Clay climate and the probable conditions which led to it. Whatever may have been the cause of the outstanding alliance of the London Clay flora with the living Indo-Malayan flora, it was one which ceased to be markedly operative before the end of the Eocene (Hordle). A change beginning in pre-Hordle times continued until the close of the Pliocene. Successive fossil floras are, on the whole, represented increasingly by living genera of wide range. Counting as genera of wide range those which are found in over two-thirds of the botanical provinces enumerated in the diagrams, we find that in the London Clay there was 1 per cent.; in the Hordle flora, 26 per cent.; in the Bembridge flora, 29 per cent.; in the Pont-de-Gail flora, 27 per cent.; in the Reuverian, 32 per cent.; in the Teglian, 48 per cent.; in the Cromerian, 46 per cent.; and, for comparison, in the living flora of Britain, 26 per cent. It is quite evident that with the passage of time from the Eocene to the Cromerian there has been a general increase in the proportion of genera of wide range represented in the successive fossil floras. But between the Cromerian and the present flora of Britain there has been a reversal of the process, a very marked drop from 46 per cent. to 26 per cent. In respect of these genera the living flora of Britain is only comparable with some of the earlier of the fossil floras, Hordle, Bembridge, Pont-de-Gail. Were it not for this abrupt drop in respect of the occurrence of wide-ranging genera, it might have been thought that wide range was merely an inverse function of age. But evidently that is not so. Other circumstances have affected the British flora, and it is worth a moment's consideration what these might have been. Almost certainly the principal ones were the changes of climate during the Pleistocene period which depleted the flora, and the isolation of Britain as an island, during the same period, which checked its re-population. Therefore, other causes besides age must be effective. One, which was certainly effective throughout the whole of the Tertiary age from the end of the Eocene onwards, was the increasingly temperate character of the flora, that is, its alliances are increasingly with living temperate genera. But from the fact that temperate forms can range into the tropics as montane forms, as well as over the temperate zones of the earth, their possible geographical range is very greatly extended. Mr. I. H. Burkill suggested to us in conversation that the increasingly herbaceous character of the flora might also have had an effect in increasing the alliance with wide-ranging genera, because, on the whole, the seeds of herbaceous plants are smaller and therefore more easily dispersed than those of trees. The subject is an interesting one, but we cannot pursue it further at present, for its only direct bearings on the work in hand are that, when we come to investigate the Diagrams of Distribution, the regional dominance which is evinced very clearly in the study of species (cf. Reid, C. & E. M., 1915, pp. 27-50), although still evinced by the genera, is rather obscured in the later Tertiaries by the number of wide-ranging forms.

(iii) *Changes in Phytogeographical Relationships.*—Turning now to consider in detail the Diagrams of Distribution of the living representatives of the Tertiary genera, we find that the succession in time of the floras from the London Clay (or perhaps it would be truer to say from the Bracklesham) period to the Cromerian is correlated with a general northward trend in phytogeographical relationships. This trend is most conspicuous in east Asia. We must consider the whole subject in some detail.

(*a*) **The Eurasian Continent.**—In the London Clay flora the dominant Eurasian relationship is with Indo-Malaya, and the most marked relationship is with the Malay Islands. The alliance with the whole of Europe and western Asia is almost negligible, but that with the tropical Himalayas, Japan, and China is of considerable importance.

In the Hordle flora the region of dominant relationship is found more to the north, in south China and Burma; but there is a strong, although subsidiary, relationship with Further India, Japan, and north China, and of less importance with the Malay regions, India, and the Himalayas. Relationship with Europe has begun to assume some importance, especially that with south Europe. Northern genera also appear, but of these we shall speak separately, in due course.

In the Bembridge flora relationship with north China and Japan takes the lead, although that with south China and Burma follows it close, and the whole Indo-Malayan relationship is still of great importance. The European and west Asian relationship has become more prominent; especially the south European and Mediterranean relationship.

In the Pont-de-Gail flora the region of dominant generic relationship is very definitely in Japan and north China, the Himalayas following close; but the Indo-Malayan relationship is still important. The west Asian and European relationship is of increasing importance, and many living genera of western Europe have established themselves.

In the Reuverian the dominance of the relationship with Japan and north China is even more apparent, and the importance of the west European, west Asian, and Himalayan relationships has increased, whilst the Indo-Malayan relationship has considerably diminished.

In the Teglian, the west Asian Himalayan and west European relationships have grown so greatly in importance that now they almost equal those with Japan and north China, which for the last time hold the position of pre-eminence.

In the Cromerian the dominant relationship has definitely passed to western Europe; a relationship still more conspicuously dominant in the living flora of Britain.

There are two points to notice in this survey of the secular changes in phytogeographical relationship between the successive Tertiary floras of west Europe and the living Eurasian floras. As already stated, the trend of the relationship is continuously northward ; a series of northward movements from the tropics (London Clay) through sub-tropical and warm-temperate regions to temperate regions (Cromer). In the second place the successive floras show changes in the nature of a sequence, a steady development, by which the flora of west Europe was transformed from one having affinity with the tropics of east Asia to one of European character. The development may be a little irregular, more rapid here and slower there, a very much greater change between the London Clay and Hordle floras than occurred later (this fact will be touched upon below, pp. 80, 81), but on the whole it is progressive—northward, cooler, and gradually more Europeanizing. At the beginning of the sequence stands the London Clay (and, probably we should add, the Bracklesham flora, which also has tropical affinity). It may be objected that it is not justifiable to draw the inference of tropical affinity for the London Clay flora, because it is extinct. We shall have to deal with this question at length later on. Meantime it is sufficient to point to the fact that our knowledge of the flora is not that of an isolated phenomenon detached from the present, but of one connected with the present by the sequence of events we have described above, a sequence which, in reversal, can be studied from the known to the unknown. This fact makes all the difference in the reliability of the evidence afforded by the flora and the interpretation it is permissible to put upon it.

We have dealt at length with the Eurasian Continent because the trend of events is more clearly defined in regard to this than to any other of the continents. Nevertheless we must examine what has happened in relation to other parts of the world.

(*b*) **The American Continent.**—The continent next in importance to Eurasia for the study of the progressive changes in phytogeographical relationships of the west European Tertiary floras is North America, because North America, like Eurasia, extends from cold-temperate regions to the tropics, and in the later Tertiaries the European floras show considerable alliance with the living American flora, a subject which will be discussed later when we come to consider climate.

The earliest stage in the relationship with which we are concerned is shown by a slight alliance between the London Clay flora and the living flora of America, chiefly of the American tropics and sub-tropics.

In the Hordle flora the American alliance has increased in importance, being equally marked in the West Indies and the United States.

In the Bembridge flora there is no great change, except that the western United States are slightly less well represented.

In the Pont-de-Gail flora the dominant alliance is with the eastern United States, but the whole American relationship continues to be important, and many genera with tropical relationships occur. It is to be noted that the alliance with the eastern United States begins to rival, and even excel, some of the east Asian alliances.

In the Reuverian the alliance with the eastern United States has slightly increased, and appears more marked because now the alliances with the warmer parts of America have diminished greatly.

In the Teglian the great increase upon the American alliance seen in the Reuverian is due in considerable part to the very large number of wide-ranging genera, but it is to be noted that in the Teglian as in the Reuverian flora the temperate alliance with America has quite outstripped the tropical. Note, also, that it is not until the Teglian period that the European alliance begins to overtop the American.

It will be observed from the above survey that, with the passage of time, the region of phytogeographic generic relationship in America moves northward, although the progress northward is not quite so clear as in Eurasia. Also it will be observed that the American relationship grows in importance with the passage of time, being much more marked in the later Tertiaries than in the earlier. The significance of this point will appear later when we consider the question of climate.

(*c*) **Tropical Africa.**—The tropical affinity of the London Clay flora and the nearness of the African Continent to Europe might lead to the expectation that the closest alliance of the flora would lie with the flora of Africa. But this is not the case. It is true that after the alliance with the Indo-Malayan region, south China, Burma, and Australia, the African alliance ranks next, but it is of small account in comparison with that of Indo-Malaya. In periods later than the London Clay, even the alliance with America is more marked than that with Africa, our nearer neighbour. The explanation must be sought in the physiography of the European and African continents, which from a time long prior to that we are now considering, have been separated, more or less completely, by an immense intervening sea across which migration seems always to have been difficult and was at times perhaps impossible. The increased African association in the later Tertiaries, like the increased association with many other regions, as for instance South America, is due, in part, to plants of wide range, and in part to montane forms. In connexion with the African alliance we may notice the quite considerable alliance between the living flora of Madagascar and that of the London Clay. It probably dates from an earlier land connexion between Africa and Madagascar.

(*d*) **Australia.**—The last continental relationship we need consider is the Australian. The generic link is of considerable importance in the earlier Tertiaries. In the later Tertiaries it is chiefly maintained by the presence of many genera of wide range.

(*e*) **The Northern Regions.**—There remains yet one more regional alliance to be considered—that with the Northern Regions of Eurasia and America. With the exception of a set-back between Pont-de-Gail and Reuver, there is a considerable increase in the proportion of north-ranging genera from the London Clay to the Cromerian. In the London Clay there is but one representative northern genus *Cornus*. The northern forms first occur in any number in the Hordle flora. The gradual increase of northern genera, viewed in connexion with the northern trend of the relic floras in the Eurasian and American continents, points very clearly to a progressive cooling of the Tertiary climate from the Middle Eocene onwards. Not only so: the symmetry of these changes in the northward movement of the relic floras both in the Old and the New World indicates the high probability of a stable

North Pole—a point, as we shall see, of very great importance when we come to consider the question of climate.

In connexion with the development of northern genera we may draw attention to a curious anomaly. There is a greater proportion of these genera in the Teglian and Cromerian floras than there is in the living flora of Britain. The explanation that suggests itself to account for this remarkable and quite unexpected fact is one we have already touched upon (p. 55), that during the late Tertiaries Britain formed part of the continent of Europe and would therefore have shared its flora more completely than it did later, when it was separated. It was during this subsequent period of (possibly interrupted) separation that the climate of Europe underwent a series of oscillations from heat to cold; changes which must have had a very impoverishing effect on a flora cut off from free immigration from surrounding countries. And, as the last climatic change has been from colder to warmer conditions, it would be the warmer element that would be the last to enter the country, benefiting by such chances of invasion as offered. Consequently, the tendency would be towards a greater preponderance of warmer forms over cooler than prevailed when the country of Great Britain was open to all immigrants alike. This is merely a suggestion; but the curious fact remains.

5. Comparison between the London Clay and Palaeocene Floras: Significance of the Facts shown

We have been considering in the foregoing pages the relation of the London Clay flora to some of the Tertiary floras of west Europe which succeeded it. We may now turn to the consideration of those which preceded it—the Palaeocene floras. The Palaeocene flora of Britain, that of the Woolwich and Reading Beds, has been so imperfectly studied that hardly any reliable information is forthcoming. The Palaeocene of France and Belgium is much better known. Although the work by Saporta may need revision, he was probably right in thinking that the climate of the early Palaeocene (Gelinden) was of warm temperate type, and may have approximated to that of south Japan (1879, p. 217); whilst the later Palaeocene of Sézanne showed more tropical affinities (p. 219). Starkie Gardner held very similar views as to the relation between the older Woolwich and Reading Beds and the newer Oldhaven Beds (Gardner and Ettingshausen, 1879, p. 2). The flora of Mull, supposed to be of Palaeocene age, seems to indicate temperate conditions (Seward and Holttum, 1924, p. 89).

The floral evidence therefore points to a change of climate as taking place during the Palaeocene, a change which had its culmination in the London Clay–Bracklesham period. We have linked these two periods together for the purpose of the immediate inquiry because the Bracklesham flora, so far as it is known from the researches of Dr. Helena Bandulska, Starkie Gardner, and others, appears to give much the same evidence regarding climate as the London Clay; and because the Lower and Middle Eocene, taken as a whole, mark an important turning-point in the floral and climatic history of western Europe. We shall have occasion, later, to examine the causes of this change in the history; for the present it is sufficient to note that the floral relationships indicate that before the London Clay–Bracklesham period the climate was warming, and that afterwards it was cooling. The result of such a change of climate would be that before the period migration would be northward in latitude and upward in altitude, and after the period southward in latitude and downward in altitude.

Under such circumstances it is probable that the cooler elements of the Palaeocene flora retreated northward during the London Clay–Bracklesham period, to return later when the climate cooled (Gardner, 1883, p. 2) ; but it would also appear probable that some of the warmer and of the more adaptable among them were able to withstand the hot conditions and live through them at the same time as a warmer type of flora was coming in. It is perhaps justifiable to interpret the more tropical floral elements of the London Clay as representing the incoming flora, and the more montane elements and the extra-tropical elements as representing, in part at least, either the older Palaeocene flora, or a contemporary montane flora ; probably the former.

If this be the true interpretation of the course of events which would ensue from the change of climate, it is not surprising to find when the London Clay genera are divided as in the table, pp. 48, 49, into those with purely tropical and those with mixed tropical and extra-tropical affinities that, except for three members of the former class, *Nipa*, *Iodes*, and *Tetrastigma*, it is members of the latter class only which occur either in floras older than or newer than the London Clay. Thus *Araucarites* (cf. *Araucaria*), *Sabal*, *Symplocos*, and *Magnolia* are recorded from older floras. They also lived through the London Clay period in west Europe and survived until later times. The same is probably true of some of the numerous Lauraceae which occur in the Palaeocene and in the London Clay, but the generic relationship of these Lauraceae in the strata of both ages is very imperfectly known. So, too, some of the unknown Juglandaceae of the Palaeocene and London Clay may belong to the same genera, but we have no means of comparing them, for one set is known from leaves and the other from fruits.

In contrast to the survival of these cooler genera none of the tropical genera, except *Nipa*, *Iodes*, and *Tetrastigma*, succeeded in surviving until the end of the Eocene, and these have never been recorded later than the Hordle flora.

It may be noted in passing that this floral evidence is in very close accord with the parallel evidence afforded by the marine fauna. This has been clearly summarized by Professor A. Morley Davies (1930, p. 307). There was an intermingling of cooler and warmer types in the Palaeocene and in the London Clay. In the early Palaeocene of Denmark the cooler types prevail ; in the later Palaeocene of Mons there is a warmer-water fauna ; and in the Lower Eocene (London Clay and Oldhaven Beds) and Middle Eocene (Lower Bracklesham Beds) 80 and 90 per cent. respectively of warm Tethyan gastropods occur (1930, p. 314).

Dr. E. I. White (1931, pp. 32–37, 42) takes a rather different view of the Landenian climate from Professor Morley Davies. His conclusions are based upon the somewhat scanty remains of marine fish in the Thanet Sands and Woolwich Beds, and the much more abundant remains in the Landenian of Belgium and

France. In these he finds only tropical and sub-tropical forms. Professor Morley Davies' conclusions are more in agreement with those of the climate suggested by the Landenian flora as interpreted by Saporta in France and Gardner in England (see p. 59). The present writers have never studied any Palaeocene floras. The apparent discrepancies shown by the three lines of evidence perhaps are due to the differential effects produced on the distribution of mollusca and marine fishes through the presence of two contending currents, one hot and one cold, and through the relation between land and water conditions produced by these currents and other contemporary changes. The climate, and consequently the flora, would react much more slowly to changes in the direction of ocean currents than would the mobile inhabitants of these currents, as Dr. White himself shows (p. 35). Therefore the warm Eocene climate would probably lag far behind the first arrival of the warm Tethyan current on the shores of west Europe. The climate appears to have depended, as we shall see later (pp. 73, 74), not merely on this single current but upon associated changes which would affect all the waters of the Northern Hemisphere.

In any case vertebrate and invertebrate palaeozoology are at one in finding that the life in the ocean was predominantly tropical or sub-tropical during the period of the London Clay, which is the period we are now considering. So that they point to ocean conditions which would accord with the growth of a tropical flora in that period.

6. Suggested Previous History of the Warmer Elements in the London Clay Flora

The question that next presents itself for solution is the probable antecedent history of the warmer elements in the London Clay flora. The key to the solution appears to lie in the presence of *Nipa*. As already stated, the living *Nipa* requires brackish water for its existence. It lives on tidal mud flats. So, doubtless, did the fossil. It is not therefore surprising to find that the only records of fossil *Nipa* come from places which, according to generally received opinion (Suess, 1900, p. 498; Arldt, 1919, p. 409, map 58), lie near the boundaries of the Eocene Tethys Sea. In making this statement we are not unmindful of the reputed finds of *Nipa* in America. But, as we state on p. 129, we are unable to accept these determinations as based on any valid evidence. *Nipa*, therefore, in its fossil distribution, appears to have been associated with the Tethys Sea.* It must have travelled to Britain

* De Saporta recognized the association of *Nipa* with the Nummulitic Sea in some degree, for he remarks on its occurrence in the London and Paris Basins around the periphery of the Parisian gulf which was associated with the sea.

Whilst going to press we have come across a passage in which W. T. Thiselton-Dyer (1878, p. 435) anticipated our suggestion of the path by which the Indo-Malayan flora reached the shores of Europe. The passage is as follows: "During the Eocene period Hindustan formed an island which was separated from the rest of Asia by a sea which extended westwards into Europe. Along the northern shore of this sea the Indo-Malayan flora flourished, extending northward as far as latitude 55°. There seems reason for believing that the oleander is in Europe a surviving type of it, and the genus, with others long extinct in the west, probably still holds in Asia much of the ground that it occupied then, though the bottom of the Nummulitic Sea has long since been elevated into land."

along the shores of the sea just as the mollusca travelled within its waters; and in the Anglo-Belgian Basin it seems to have reached its northernmost limit, for no more northerly records are known. It is making no great assumption, therefore, to suggest that along with *Nipa* came the remainder of the lowland tropical Indo-Malayan-African element in the London Clay flora, which here, for a time, established itself in its (so far as is at present known) most northerly position. It is further probable that it was able to meet the opposition of the previously established flora because this flora had been subjected to a degree of heat for which it was not adapted and was therefore enfeebled and depleted.

7. Summary of Conclusions as to the Affinity and General Character of the London Clay Flora

In conclusion we find that from whatever point of view we regard the London Clay flora—whether from the families represented, or the genera, or its ligneous character—we reach the same conclusion. Its affinities are tropical; the bulk of the flora being allied to genera inhabiting the tropical rain-forests of the present day, and the greater number of its allies being found in Indo-Malaya. Beccari (1904, p. 381), writing of the primaeval rain-forest of Borneo, describes it in the following manner: " It is characterized by the great size of the arboreal vegetation, by the infinite variety of species which form it, and by the great number of peculiar forms." His description further states that the loftier trees, many of which rise to the height of 150 or 200 feet, form a thick overhead canopy through which the sun's rays scarcely penetrate. Beneath the shade of these forest giants is a dense growth of smaller trees and shrubs festooned with epiphytes, the whole being tangled into an impenetrable jungle by a strangling mass of lianas and creepers. " The *Nipa* palm forms usually a dense hedge in front of the mass of arboreal vegetation as far as salt water extends. It evidently requires a swampy ground on which it spreads its big stems, which resemble both in aspect and dimensions those of a cocoanut palm lying on the ground " (p. 81).

Such must have been the general aspect of the London Clay rain-forest. Probably in this northern latitude the trees did not attain the dimensions which they reach in the tropics. Indeed, the fact that a very large proportion of the fruits of *Nipa* in the London Clay are undersized, although others attain the normal dimensions of the living *N. fruticans*, suggests that *Nipa* at least was stunted.

In making this comparison of the London Clay forest with the rain-forests of Indo-Malaya there are certain very striking differences which must be noted. In the first place, although there are numerous creepers and twining shrubs, there are comparatively few true lianas, the all but complete absence of Leguminosae being remarkable. Again, although at every turn we have looked for them, we have found no remains of any Dipterocarpaceae, Pandanaceae, or *Casuarina*, nor of the mangrove arboreal vegetation. Yet all these in the present day form some of the most conspicuous and characteristic elements in the lowland vegetation of Indo-Malaya. To what cause this absence is due we cannot tell. It may have been that the climate was unsuited to them, or it may be merely chance—perhaps they never reached the London Clay forest land, or perhaps their remains have not been preserved, or, if preserved, they have not chanced to be found—or, again, it may be that they are of later development than the London Clay period. We have no evidence by which to tell.

VI. CLIMATE

The conclusion that the affinity of the London Clay flora is mainly tropical is in accordance with received opinion, albeit opinion based for the most part, as we have seen, on very unsound evidence. Nevertheless it is disquieting, for this reason: that to account for the presence of tropical life, in past geological times, within what are now temperate regions, and of temperate or warm temperate life in what are now arctic regions, constitutes one of the most vexed of climatological problems.

In attempting in the following pages to seek a satisfactory solution of the problem we shall have to take cognizance of the various suggestions which from time to time have been put forward in order to account for the presence of apparently warm floras in northern regions.

1. Examination of the Explanations of the occurrence of a Tropical Flora, based on Theories of Water Transport

(i) *Transport by River*.—The first suggestion to account for the tropical character of the London Clay flora was that of Bowerbank, who wrote (1840, p. 8), the " formation . . . is strikingly stamped as having been the delta of an immense river, which probably flowed from near the Equator towards the spot where the interesting remains are now so abundantly deposited." There are two parts to this hypothesis: that the remains are the detritus of a great river; and that the river rose near the equator carrying with it the remains of tropical plants and animals. The first part of the hypothesis is almost certainly correct and has already been dealt with (pp. 20, 21). It is highly probable that the remains were, in great part at least, swept down by a great river.

The second part of Bowerbank's hypothesis will not stand investigation. There is one feature of Eocene physiography about which geologists are agreed, namely, the existence of the great Nummulitic or Tethys Sea, of which we have already spoken, although there is some diversity of opinion as to its exact extent at different times. It covered, probably with interruptions, the whole Mediterranean basin together with south-central Europe, including the Alps, Carpathians, and Balkans; the north of Africa, including the Atlas, Sahara, and Egypt; and in Asia, Arabia, Palestine, Persia, and the Himalayas, to the farthest confines of India. This " ocean-like " sea, moreover, communicated with the Indian Ocean. Where then was there any tropical region in which the river could have had its source? The answer is: There was none. All were cut off by sea.

There is a further consideration which excludes the possibility of accounting for the London Clay flora as an alien flora swept from far-away tropical regions by a great river. *Nipa* is one of the most tropical as well as the commonest of its constituents. And *Nipa* cannot have grown in the upper reaches of any river, because it must have salt water to support it. It cannot therefore have been brought by a river except through its tidal reaches alone. Consequently it must have grown near the region of deposition or have been transported by ocean currents from some tropical shore.

(ii) *Transport by Ocean Currents.*—We have spoken above in reference to *Nipa* of the possibility of transport by ocean currents. The possibility is a very real one, and needs investigation. The studies of Schimper (1903, pp. 28–31), Guppy (1906), and others, have shown that many fruits and seeds can float for a very long time, and be carried to great distances by ocean-currents.

"The stranded West Indian beans of Caesalpinia, Mucuna, and Entada . . . have been drifted there [Scandinavian coast] for ages by the Gulf Stream, and lie in some cases semifossilized in the adjacent peat-bog" (Guppy, p. 4). But it is the fruits and seeds of littoral plants which are thus adapted for long flotation and transport. Guppy gives the results of his observations on the transport and dispersal of fruits and seeds by ocean-currents as follows (p. 22):

"(1) . . . The far greater proportion of species with buoyant seeds and seed vessels amongst the shore plants than among the inland plants."

"(2) . . . Almost all the seeds or fruits that float unharmed for long periods belong to shore plants."

"(3) . . . When a genus has both inland and littoral species, the seeds or fruits of the coast species as a rule float for a long time whilst those of the inland species either sink at once or float only for a short period."

Although one littoral species, *Nipa Burtini*, is the most abundant of any among the Sheppey fruits, other species which are also, perhaps, littoral are comparatively rare. Inland genera, either lowland or montane, form the bulk of the flora. But if so, according to Guppy's observations, the fruits and seeds would not have been adapted for long flotation and far transport. And, indeed, the structure of the greater part of the London Clay fruits suggests that this was the case. Very few seem to show special adaptation for floating. Whenever we have observed such structures, as in *Lobaticarpum variabile* (p. 314), we have noted them.

There is, moreover, another consideration which strongly negatives the probability, indeed one might say the possibility, of the Sheppey flora being transported from a tropical to a temperate latitude. If a present-day example of such transport be examined, say that to which we have already referred, the flotsam of the Gulf Stream on the western shores of Europe, it is found that there is always an admixture of local forms of life with the tropical; and the local forms outnumber the tropical. This cannot have been the case with the Sheppey fruits and seeds. It is the highly tropical forms which are most numerous; not only generically, but individually. The most abundant species, as we have seen, is *Nipa Burtini*; other genera of tropical alliance which are extremely numerous are *Ochrosoidea sheppeyensis* (cf. *Ochrosia*), *Dracontomelon subglobosum*, *D. minimum*, and the hundreds of specimens of Icacinaceae; and we might probably add the equally numerous specimens of Anonaceae, for this family is almost exclusively tropical at the present day. The only species with cooler affinities which is really abundant is *Petrophiloides Richardsonii*. It is true, as we have seen, that there is an admixture of tropical lowland genera with others which may also be montane or, alternatively, extra-tropical, but such an admixture is only what would be expected in the drift carried by a tropical river, which would sweep down *débris* from its higher as well as its lower reaches. Dr. A. Kerr (1930, pp. 112–114), describing the beach-drift on the island of Kaw Tao, in the Gulf of Siam, records eighteen littoral species, nine estuarine, and twenty inland species. Also he remarks, " Inland species of plants being so much more numerous than littoral and estuarine species combined, it is not surprising their fruits were so well represented in the drift, even though their facilities for reaching the sea may be fewer." Beccari also describes the way in which fruits and seeds are swept downstream from inland areas : " On the slopes of mountains the number of individuals of a given species is greater than in the valleys or on the plains ; whilst on these the variety of species is larger, for it is here that fruits and seeds carried by the stream and spread by frequent inundations accumulate in large quantities " (1904, p. 68). But the river drift is also carried out to sea, so that in describing how women on the coast of Borneo were busily engaged in searching for resin, " the product of some dipterocarp abounding in the forests of the interior and carried down by floods to the sea," he remarks, " Some distance above the fort [where the women were collecting the resin] a small stream debouched, and after heavy rain I have seen this carry down large quantities of mud, which covered up the flotsam and jetsam cast up by the sea. This . . . gives an undoubted instance of a littoral marine formation which consists nearly entirely of land and freshwater vegetable remains " (Beccari, p. 258). The presence of lowland and (possibly) montane and extra-tropical forms in the London Clay is therefore better explained as the drift gathered from both upper and lower reaches of the same river and swept out to sea beyond its mouth, than as a mixed ocean drift derived in part from the far distant tropics and in part from the local, temperate vegetation.

It is impossible, therefore, to accept either the theory of transport by a river, or by ocean-currents, from some far distant tropical region, to account for the presence of this flora of tropical affinity in the London Clay. *The plants must have grown comparatively near the place of deposition.* It is a conclusion supported by the character of the floral remains themselves ; for it is unlikely that in very far transported material so many hundreds of individuals belonging to the same species would be found deposited together, as happens in several instances in the London Clay of Sheppey.

2. Explanations based on the Supposed Unreliability of Fossil Plants as Indexes of Climate

Another argument has been frequently brought forward to explain away the climatic significance of tropical, or warm, floras in temperate or polar latitudes. It has been suggested, chiefly in connexion with Arctic floras, that plants are not to be relied on as indexes of climate. Thus Professor Berry in a recent publication

(1930*a*, p. 19) has strongly "emphasized the lack of climatic value of the plant types which palaeobotanists have relied upon as indicating tropical conditions." He then proceeds to deal with the subject under three headings. The first, which is chiefly concerned with the formation of peat, is an argument which in this research does not concern us as it does not consort with the nature of the deposit. Under his second head he states, "the tropical idea relies on representatives of long lived, vigorous groups with very many species, which either in the past or in the present have become adapted to a variety of habitats, as is usually the case in large vigorous groups of all kinds of organisms. . . . A third source of error is the common assumption that because a particular type of plant has its home in the equatorial zone it is necessarily a tropical plant." Professor Seward (1926, p. 160) also writes, "plants themselves have in all probability changed in their reaction to external factors."

It is entirely justifiable to bring forward such arguments, but it is equally necessary to scrutinize them very carefully in order to discover what weight they may have in any particular case. The arguments for the unreliability of plants as indexes of climate fall, then, under two heads :

(i) *Those based on the fact that many tropical genera contain extra-tropical species.*

(ii) *Those based on the assumption that with the passage of time plants may have changed in their reactions to climate.*

We will examine these arguments separately in relation to the London Clay.

(i) There is a certain amount of evidence to support the first contention, which resolves itself into this : That inferences as to climate cannot always be based on the warmest elements in a flora. Whether they can depends upon two things. In the first place, on the proportion of the warm elements present. This is a point of paramount importance. *It is the bulk of the flora that must be taken as the index of the climate.* In almost every flora, whether living or fossil, there will be found some more or less aberrant species. For instance, the occurrence of such species as *Arbutus unedo*, *Erica mediterranea*, *Daboecia polifolia*, etc., in the west of Ireland does not indicate a Mediterranean type of climate. Similarly, in almost every fossil flora we have met with, a few aberrant species are to be found—survivals, forerunners—whatever they may be. In the second place, in the case of floras with tropical alliance, the evidence for tropical conditions depends upon whether the bulk of the flora is of lowland tropical affinity or not. If, as in the case of the London Clay, it is, there can be no doubt but that a tropical climate is in question. Only, as we shall see later, it is the plant, and not man that must define the word "tropical."

(ii) The second argument against the reliability of plants as indexes of climate is that based on the assumption of change in adaptability. Its chief exponents have been Professor E. W. Berry and Professor A. C. Seward ; and both have sought to support their argument not only by reference to genera with tropical and extra-tropical range, but as well by reference to the adaptation of plants under cultivation. Thus Professor Berry cites "Ingas (cultivated) at 10,000 feet in the Andes perfectly hardy" (1930*a*, p. 22). And Professor Seward (1926, p. 160) refers to *Platanus*, *Ginkgo*, and *Sciadopitys* surviving, and in the case of *Sciadopitys*, thriving, in climates much colder than those to which they are native. The latter author, in a recent " Discussion on Geological Climates " at a meeting of the Royal Society (1930), whilst acknowledging (p. 303) " that fossil floras are of very great value as guides to changes in climate," thinks the value has been over-estimated and argues that the floras are extinct, and that with regard to the Cretaceous and Tertiary floras " we must remember that the species are practically all different from any that are now living. We know at the present time what tremendous differences there often are in power of resistance to climatic conditions between species belonging to the same genus."

It is true that in the present day some plants—we will here confine our inquiries to flowering plants—show a certain power of adaptability to climate under conditions of cultivation, but such slight evidence, it seems to us, can count for very little against the general evidence of plant distribution. The distribution of living families shows that approximately 20 per cent. have been quite unable to adapt themselves to any except special conditions ; the greater part because they are exclusively tropical, and a lesser part because they are exclusively extra-tropical. About 50 per cent. show very little power of adaptation. They are either tropical or extra-tropical, as the case may be, with the exception, sometimes, of a few genera or, often, of a few species only. The remaining 30 per cent. show equal adaptability for either tropical or extra-tropical life. The weight of evidence from the living world, therefore, does not indicate any very general power of adaptability among flowering plants as a whole in the present day. And it would be rash to attribute any greater power of adaptability in the past without very definite evidence to support it. The survival of a few individuals under cultivation in exceptional climates does not appear to us to constitute such evidence ; because survival and adaptation under natural conditions involves not only the survival of a few well-tended adults but, as well, reproduction and the survival of immature forms, in competition with plants which may be better adapted for the habitat. How true this is, is shown by the investigations of Dr. John Phillips on the Knysna forest in South Africa, where he had under observation certain South African forest trees. In summarizing his results he states : " Mortality was found to be greatest in flowers, fruits, and young regeneration. . . . In older-stage regeneration . . . in proportion [it] was much less." Also he found that the biological and ecological factors responsible for high mortality were concerned, almost exclusively, with flowering, pollination, fruiting, germination, and immature plants (*Nature*, 1931, pp. 851, 852).

Having examined the evidence of adaptability to be derived from living plants, that to be derived from fossil plants may next be considered. Are there any real indications of a greater power of adaptability among plants in the past than in the present ? In the " Discussion on Geological Climates," already referred to, Dr. Hamshaw Thomas made a very pertinent observation (1930, p. 316). He stated that " there seems no indication in the geological record of any gradual acclimatization of the plants which existed in Eocene times in Europe as the Great Ice Age approached and the climates became colder, and presumably, drier." Not a single genus that lived in Britain during the London Clay period was able by " gradual acclimatization " to survive into the Cromerian. The bulk of the genera did not even survive to the end of the Eocene. Of those which did survive when somewhat cooler conditions supervened after the Middle Eocene (Bracklesham), it is probable that none succeeded in surviving climatic conditions which, accepting the general evidence of fossil floras at its face value, were in any degree different from those which they survive at the present day. We will trace the subsequent history of these survivors, taking them in the order in which they seem to have been exterminated in west Europe, beginning with those first killed. *Nipa*, *Iodes*, and *Tetrastigma* have all been traced into the Hordle flora (Chandler, 1925–26), at which time the climate would appear to have been sub-tropical, about that of Burma at the present day. But except *Nipa* these genera grow in Burma at the present time, and *Nipa* grows in the Ganges delta.

Palaeorhodomyrtus, or *Rhodomyrtus*, has been traced into the Bournemouth Beds (Bandulska, 1931, p. 657), and into beds of reputed Eocene age in Finistère (Reid, 1930, p. 48). But whatever the exact Eocene age of the Finistère beds may be—the floral evidence certainly indicates warm Eocene—no Middle or Upper Eocene climate in west Europe was cooler than sub-tropical if we accept the evidence at its face value. At the present day *Rhodomyrtus* is chiefly tropical, but also ranges north into Japan, and south into New South Wales. Therefore the range is, possibly, greater in the present than the past.

Araucarites is found in many deposits of Oligocene age (sub-tropical to warm-temperate). The living genus *Araucaria* ranges from south Chile to Brazil, and from east Australia to the Norfolk Islands.

Sabal, *Ampelopsis*, and *Ardisia* have been found as late as the Miocene when warm-temperate conditions seem to have prevailed. At the present time all three genera range from the tropics to warm-temperate latitudes.

Symplocos and *Ehretia* have both been found in the Mio-Pliocene (warm-temperate). At the present day both range from the tropics to warm-temperate latitudes.

Magnolia, *Meliosma*, *Cinnamomum*, and *Nyssa* all occur as late as the Lower Pliocene (warm-temperate). In the present day they also range from the tropics to warm-temperate latitudes

Vitis survived in west Europe until the Middle Pliocene (temperate). *Vitis* now ranges from the tropics into temperate latitudes (Canada).

Hence when we follow up the history of the London Clay genera we find no evidence to warrant the assumption that we can explain the presence of the mass of genera with tropical affinities by postulating a greater power of adaptability in the past than in the present. This question of greater adaptability in the past is so important that it is well to inquire what further evidence there is to indicate whether plants are indeed reliable indexes of climate. The best evidence is afforded by Pleistocene floras when changes of climate were in both directions, from heat to cold, and from cold to heat, as is known apart from floral evidence. What happened to these floras ?

It is known that the temperate conditions of the Cromerian (see references, p. 51), Clacton (Reid & Chandler, 1923*a*), Stone (Reid, C., 1893), and West Wittering (Reid, C., 1899, pp. 94–96) times were all followed by cooler conditions. But none of the warmer elements in the contemporaneous floras survived those cooler conditions in Britain by adapting themselves. *Hypecoum procumbens*, *Corema intermedia*, *Trapa natans* (all Cromer) ; *Picea excelsa* (Clacton) ; *Acer monspessulanum* (Stone) ; *Najas minor* and *Najas graminea* (both West Wittering) all failed to survive in Britain ; whilst two species of *Crataegus* were exterminated (Reid & Chandler, 1923*a*, pp. 621, 622) ; and on the Continent, *Brasenia purpurea* was exterminated throughout the whole of Europe.

Or, again, consider the change from colder to warmer conditions, such as followed upon the time of the Arctic floras. Such cold-climate plants as survived in Britain did so, not by adapting themselves, but by ascending the mountains. If they did not reach the mountains they were killed ; either exterminated in Britain, or extinguished entirely. Thus among plants occurring in the Barnwell (Cambridge) Arctic flora (Chandler, 1921), *Ranunculus aconitifolius*, *Papaver alpinum*, *Arenaria sedoides*, *Arenaria biflora*, *Gentiana cruciata*, *Armeria arctica*, *Salix polaris*, were exterminated in Britain as the climate warmed, although they continue to live outside Britain as Arctic or alpine plants. *Silene caelata* Reid and *Linum praecursor* Reid were entirely exterminated. Those colder elements in the Barnwell flora which still survive in Britain do so only as mountain plants. They are *Thalictrum alpinum*, *Arenaria gothica*, *Potentilla alpestris*, *Dryas octopetala*, *Saxifraga oppositifolia*, *Vaccinium uliginosum*, *Primula scotica*, *Polygonum viviparum*, *Salix Lapponum*, *Salix reticulata*, *Betula nana*, *Carex lagopina*, *Carex ustulata*, and *Carex atrata*.

Exactly similar evidence, which we need not here repeat, is furnished by the Arctic flora of the Lea Valley (Reid. C., 1916 ; Reid & Chandler, 1923), and by other Arctic floras. Consequently in whatever direction the changes of climate have been during the Pleistocene, whether from warmth to cold, or cold to warmth, the evidence is the same. Plants have not been able to escape destruction by adapting themselves, but by migration. Similar evidence of the ebb and flow of plant life with change of climate is shown by the study of post-glacial peats by means of pollen analysis, on which subject an immense literature has come into being. In conclusion then, there is no evidence from the London Clay and the succeeding Tertiary and Pleistocene floras to show any greater degree of adaptability among genera in the past than among the same genera at the present time. Nor is there any evidence that plants escaped destruction by adapting themselves to changes in climate. On the contrary the evidence shows that when they escaped destruction it was only by migration to suitable new habitats. Consequently it must be accepted that plants are true indexes of climate ; *only it must be the bulk of the flora that interprets the climate, not a few exceptions.*

But there is still one other side of the argument in regard to the unreliability of plants as indexes of climate which must be considered before leaving the subject. The plea of unreliability has chiefly been urged, and accepted, on the ground that the species are extinct. The plea of extinction is well founded as regards Mesozoic and all earlier floras. It is not well founded as regards all Tertiary floras. Throughout the Pliocene living and extinct species are found side by side, but, when the latter are interpreted by their nearest living representatives, both yield the same evidence as to geographical distribution and climate. Consequently there is no reason to discount the evidence of the extinct species. As we pass backwards through the Pliocene we meet floras with ever diminishing proportions of living species until we reach those in which are no living species at all. (The oldest flora in which we have ourselves found living species is the Mio-Pliocene of Pont-de-Gail.) Yet there is no dislocation in regard to the evidence as to distribution and climatic sequence in consequence of this passage from the living species to the extinct. That the older floras are as reliable as the newer is shown by the generally uniform development of the sequence of events in the Diagrams of Distribution (p. 54). Again, we may pass backwards to the time when even many genera were extinct, as in the London Clay. But when we can trace their affinity, we find that the extinct genera indicate through their living allies the same phytogeographical relationship, and hence climate, as do the living genera. Consequently we cannot discount the evidence of such genera. Theirs is as reliable as that of the living genera, since the two agree. Moreover, they are both supported by the evidence of the families represented. Judged by such standards the flora of the London Clay can only be regarded as tropical. And we have seen that it grew near the place of deposition. Consequently we are compelled to seek some further explanation of the presence of a tropical rain-forest flora of dominantly Indo-Malayan type, which grew in approximately latitude 50° N. It is necessary to stress the Indo-Malayan character of the flora, for none of the explanations so far considered can throw any light upon it, and it must be accounted for.

3. Explanations based on Theories of Change in World Physiography

(i) *Preliminary Statement of Certain Facts and Problems which in the Authors' Opinion require Explanation.*—Before we enter upon the main inquiry we must state certain conclusions, to which previous work on Tertiary floras has led us, in regard to the probable course of plant history from the end of the Eocene onwards (Reid, C. & E. M., 1910, p. 193; 1915, pp. 15–24; Reid, E. M., 1920*a*, pp. 145–161; Chandler, 1925, pp. 5–8; Reid & Chandler, 1926, pp. 13–22). The conclusions are based upon the present distribution of the relic floras of the west European Tertiaries. The facts are the following: (1) The Tertiary floras of west Europe, from the Eocene onwards, form a continually cooler and cooler succession down the ages. (2) Except from the Cromerian, and perhaps one should add, the Teglian, fewer Tertiary relics survive in that part of Eurasia which lies north of the latitudinal seas and mountain ranges than have survived in the Far East and North America, where there are no latitudinal seas and mountain ranges but, instead, mountain ranges which run north and south. (3) More Tertiary relics survived in the Far East than in North America. (4) Very few Tertiary relics of west European floras, except those of the earlier Tertiaries, before the trans-continental mountain ranges were formed, are found in Africa or India, that is, south of the barriers.

The simplest explanation of the above facts seems to be that under the stress of a continually cooling climate a succession of ever cooler and cooler circumpolar floras was driven southward ; that where the southward way to suitable climates was barred, as in Eurasia, the floras perished, never reaching, or only very sparingly reaching, either Africa or India, but leaving their remains in the fossil plant beds of Europe and Asia. That where the way was open, through all the climatic zones to the equator, they survived in such regions as best suited their needs—the hotter floras in the tropical and sub-tropical regions ; the cooler in the temperate and warm-temperate regions. But since it is with the flora of the Far East that throughout the Tertiary period the successive European floras are most nearly allied, this region must always have been in closer plant relationship with Europe than was America. That is, it was easier of access for plants.

It will be observed that the above hypotheses of successive southward migrations, with extermination and survival depending on the presence or absence of latitudinal barriers, involves the assumption that the poles and equator maintained their present positions whilst these migrations were in progress. The best evidence of an approximately stationary pole is afforded by the Eocene temperate circumpolar floras ; but our Diagrams of Distribution (p. 54) very clearly offer similar evidence. So, also, does some recent work by Professor Kryshtofovich, of Leningrad (1929, p. 309). He recognizes not only the Arctic circumpolar zone but a more southern zone. " The whole vast territory embracing the middle zone of Siberia, Northern Turkestan, Manchuria, Corea, Sakhalin, and the northern part of Japan, as well as, in America, Alaska and the adjacent territory, was in the first half of the Tertiary period, at least as late as the Lower Miocene, under the domination of a tediously monotonous summer-green forest flora." It is only fair to state that Professor Kryshtofovich himself does not interpret his work, of which the above is only a portion, as indicating a stable North Pole ; but to us it seems to do so.

According to the above views of migration there are five principal facts which require explanation.

(*a*) **The hot climate of the London Clay and Bracklesham periods.**

(*b*) **The later gradual cooling of the Northern Hemisphere.**

(*c*) **Such a disposition of continents and oceans as would account for the present distribution of the living representatives of European Tertiary plants.**

(*d*) **An approximately stable North Pole.**

(*e*) **A hot flora of dominantly Indo-Malayan affinity in the London Clay.**

At different times various hypotheses have been put forward to account for the great changes of climate which geology and palaeobotany indicate as having occurred in past geological times. We are here concerned only with such changes as happened during the Tertiary period, and not with the oscillations of climate which occurred in the succeeding Pleistocene period. Two only of the hypotheses demand serious consideration, namely, the geophysical hypothesis of the late Professor A. Wegener, and the physiographical hypothesis of Dr. C. E. P. Brooks, because the astronomical theory of Croll, it is generally considered, demands a periodicity in the succession of changes which is not in accord with geological facts. We will inquire in what degree these two hypotheses are capable of meeting the demands we have put forward.

(ii) *Wegener's Theory in Relation to the Above Facts and Problems.*—We are quite unqualified to offer any criticism of the theory as a whole; and must therefore confine our observations to its contacts with Tertiary palaeobotany, and its ability to explain the facts and problems stated above. We will take these in order.

(*a*) **and** (*b*).—So far as our first and second demands are concerned—for a hot London Clay and Middle Eocene climate, followed by a succession of cooler and cooler climates—the hypothesis, naturally, meets them, because the facts concerning the various Tertiary floras, their climatic indications, and their locations, form part of the foundation upon which Professors Köppen and Wegener build their arguments as to the position of the Eocene equator and poles, and those of the later Tertiary periods (Köppen and Wegener, 1924, chap. iv).

(*c*) **Such a disposition of continents and oceans as will account for the present distribution of Tertiary relic floras.**—With regard to our third demand, for a closer land connexion between west Europe and the Far East than between west Europe and North America, and for a closer land connexion with North America in the late than in the early Tertiary period, we note that one of the most important parts of Wegener's hypothesis is the following: After being assembled as one great land-mass, the continents drifted apart. The only point in relation to this drift that concerns us is that America is assumed to have drifted away from Africa and Europe, the rift beginning in the south and working northwards. It is further assumed that the separation was not completed until the end of the Tertiary period, up to which time the British Isles remained in contact with Newfoundland. Had this been the case, Britain and the west of Europe would have lain in such close juxtaposition with America that it would be natural to expect that they would very largely share a common flora; much more largely than west Europe and the Far East, which are 120° of longitude apart. Also we should expect to find that the floral relationship was closest in the early Tertiary period, and diminished as the rift between America and Europe developed. Consequently, seeing that Europe itself was not able to conserve its own Tertiary floras, for reasons which we have suggested above—reasons, be it remembered, which would not operate either in America or the Far East—it is to America we should look as the chief conservator of the west European Tertiary relics; and especially should we look for the relics of early Tertiary plants. Had they reached America in any great numbers, there was no reason why a large proportion of the plants should not have been preserved, as a small proportion undoubtedly was. Yet what are the facts? It is not in America that the bulk of the Tertiary plants are preserved, but in the Far East. And a far greater proportion of late, than of early Tertiary plants are preserved in America.

Consequently, as regards our third demand, Wegener's hypothesis leads to the following anomalous conclusions: (1) That although America was, by hypothesis, our nearest neighbour and could have conserved our floras, yet it is in the Far East, 120° of longitude away, that the Tertiary floras are best conserved. (2) That as, by hypothesis, the separation between the continents of Europe and America grew greater, so, in actuality, did the alliance between their floras become closer. The hypothesis does not agree with the facts. It will not hold.

(*d*) **For approximately stable poles.**—With regard to our fourth demand—that for an approximately stable pole—Wegener's hypothesis requires as one of its essential conditions moving poles and equator.

(*e*) **The dominance of the Indo-Malayan element in the flora, as opposed to the tropical African and American elements.**—The dominance of the Indo-Malayan element in the London Clay flora is one of its most outstanding features. Why should the flora of a region removed from Britain by 120° of longitude have so enormously greater affinity with that of the London Clay than either that of tropical Africa or America, when Africa is our nearest neighbour in the present, and, according to Wegener, America was an even nearer neighbour in the past? The hypothesis gives no answer.

In conclusion, therefore, we find the hypothesis cannot account for the Indo-Malayan character of the London Clay flora, and that it is contrary to the facts of distribution of the west European relic floras, which require a closer floral relationship between the Far East and west Europe than between America and west Europe, and demand, moreover, stable poles and equator. The floral evidence points, in our opinion, to the permanence of the Atlantic Ocean.

We cannot therefore accept Wegener's hypothesis as offering the true explanation of Tertiary history.

(*iii*) *Dr. C. E. P. Brooks' Hypothesis in Relation to the Facts and Problems of Section* (*i*).—The hypothesis associated with the name of Dr. C. E. P. Brooks (1925; 1925*a*, p. 87; 1926) seeks to explain the problems of past changes of climate chiefly on geophysical grounds: Changes in the distribution of sea and land, with consequent changes in the direction of ocean currents, changes in ocean temperatures, and changes in ocean and atmospheric circulation. The hypothesis accepts as its basis the general permanence of the great oceans and continents throughout Cretaceous and Tertiary times, only assuming such modifications in their peripheries and in the distribution of sea and land in certain areas, as geology suggests to have taken place. The most important of these changes, from the point of view of our present inquiry, that which it is assumed exerted the most important effect on the Tertiary climate, is the transgression of the great Tethys Sea over a region which included much of south central Europe and North Africa. This sea had arms extending north through Britain to the Atlantic Ocean, and by way of a narrow branch through the Ural Region, to the Arctic Ocean. It also connected widely with the Indian Ocean.

It is upon these very generally accepted geological facts that the hypothesis is based. Dr. Brooks' original statement is as follows: "If from any cause, such as a difference in the amount of solar radiation or in the land and sea distribution, the akryogenous winter temperature over the Arctic Ocean was only as much as four or five degrees above the present, there would be a complete absence of floating sea ice, and the *actual* winter temperature over the Arctic would be thirty degrees higher. . . . The problem of warm polar climates is now greatly simplified; we have to account for a temperature change of less than five degrees instead of more than thirty. . . .

" The most favourable distribution of land conceivable for polar temperature is given by a number of long narrow islands extending from low to high latitudes, separated by wide deep channels. This distribution . . . was approached to some extent during parts of the Mesozoic and Tertiary periods. . . . In the Middle Eocene, according to a reconstruction by Matthew, the circumpolar ring was broken by three broad gaps, an enlarged Behring Strait, the present Atlantic gap, and the Obic Sea which separated Europe from Asia."

We are no more qualified to pass criticism on the general merits of Dr. Brooks' hypothesis than on that of Professor Wegener. All we can do is to test it in relation to the facts of Tertiary palaeobotany as we find them. We will therefore apply them to the consideration of the five demands set forth on p. 71.

(*a*) **A tropical London Clay climate.**—In the first place the question arises of a tropical London Clay and Bracklesham climate. Having reached the conclusion that Professor Wegener's hypothesis of continental drift and of a shifting pole was contrary to the facts of plant distribution, we applied to Dr. C. E. P. Brooks to know whether on the basis of his hypothesis he could postulate a climate in about latitude 50° N., during the Eocene, which would be capable of supporting a truly tropical flora. We sent him our Diagrams of Distribution, and he most kindly read through the draft of this section on climate, making several valuable suggestions which we have incorporated in the text. He gave his opinion as follows (letter, December 3, 1930): " The average temperature of Rangoon is 81° F. and of Calcutta 79° F., even of Hong Kong 72° F., and it seems improbable that latitude 50° could ever have reached quite this level. I should put the maximum somewhere about 65° and almost certainly not as high as 70° F. (without help from increased solar radiation or some other extra-terrestrial factor). The increase would be mainly in the winter temperature, when I suppose it would be most helpful, but it would not give the climate of the tropics at sea-level."

The hypothesis of change in solar radiation to which Dr. Brooks refers has been used very effectively by Dr. G. C. Simpson (1930, pp. 1–34) to give a possible explanation of the occurrence of glacial and interglacial periods during the Great Ice Age. Dr. Simpson states as his opinion that increase in solar radiation would result in increased cloud and precipitation rather than in large changes of temperature, although he considers there would be some increase of temperature in all parts of the world; but more marked at the equator than at the poles. In the " Discussion on Geological Climate " (1930*a*, p. 302) Dr. Simpson further stated his opinion that " changes of this nature, limited in magnitude and of relatively short period (in the geological sense) have always occurred in all geological periods, due to periodic variations in the intensity of solar radiation." But he added: " The large climatic variations [such as the one we are now considering in connexion with the London Clay flora] . . . can only be explained by Wegener's hypothesis." An hypothesis that the present authors cannot accept.

Dr. Brooks in his letter makes it plain that in his opinion his hypothesis will not, alone, account for a climate able to support the London Clay flora, but that, by invoking the aid of Dr. Simpson's hypothesis of change in solar radiation, the requirements would be more nearly met. At least the two hypotheses together have the merit of postulating the kind of climate that would be required by the Eocene flora, if we may judge by the needs of its living representatives—an intense degree of precipitation, a soil always loaded with moisture, a climate always equable with warm winters.

Yet when we had reached this conclusion we could not feel satisfied that we had really solved the problem of the existence of this flora in approximately the latitude of Britain. We therefore began to consider whether any further evidence could be derived either from the fossil flora itself, or from the representative living floras. What exactly are the climatic conditions which support the tropical rain-forests? Whilst we were pondering these questions two facts struck us as having a most important bearing on the subject. The one was suggested by the presence of *Nipa* in the London Clay; the other by a passage in Beccari's "Wanderings in the Great Forests of Borneo" (1904), in which he lays much stress on the comparative coolness and great moistness of the rain-forests.

As we have already seen, *Nipa* must have reached the London Clay foreshore along the shores of the Tethys Sea; and on the London Clay strand it was living at its most northerly limit. Therefore, presumably, the whole tropical element in the London Clay flora was also living at its most northerly limit. Consequently what we had to account for was not, as we had at first imagined, a tropical flora living, as in the Malayan forests, at its norm of temperature, but a flora living at the lowest extreme of temperature that would permit of its growth. What would such a temperature be? What conditions, climatic and otherwise, will permit of tropical rain-forests growing in extra-tropical regions, either of latitude or altitude? Is moisture one of these conditions and is it more important, perhaps, than temperature as a limiting factor? The passage from Beccari, to which we have already referred, suggested that it might be. He states (p. 381): "The soil which nourishes the forest trees of Borneo, especially in the plains, is always loaded with moisture, and at the same time is never too much heated, being sheltered by the dense foliage of the trees themselves. For this reason the greater number of the tropical sylvan plants, living on sea-level, only flourish under a moderate temperature, say from 70° to 90°. When I use the term forest, I refer only to that which is really primeval." Might tropical moisture, rather than strictly tropical temperature, have been the governing factor which permitted of the growth of this ancient tropical forest in latitude 50°, or thereabouts?

As a beginning of our inquiry we applied to Major R. W. G. Hingston, the leader of the Oxford University expedition to British Guiana in 1929. He informed us that the average temperature of the canopy in the rain-forests of British Guiana was found to be about 7° F. higher, on an average, than that of the ground-level.

This observation corresponds with one published by Forrest Shreve (1914, p. 109), who writes : " The differences between the climate at the floor of the forest and in its canopy are as great as the normal differences between widely separated places." It also corresponds with Beccari's statement quoted above as to the conditions under which the undergrowth of the rain-forests flourishes. As evidence of the effect of moisture in permitting the growth of rain-forest in comparatively cool surroundings, Major Hingston drew our attention to the rain-forest of the Victoria Falls which owes its existence to the spray from the Zambesi keeping it continually drenched with moisture, in a country otherwise dry and supporting only a scrub vegetation. This forest, at the height of 3,000 feet, is recognized as a typical rain-forest of tropical type, we are informed by Mr. J. Hutchinson, who has himself visited it.

So far the evidence supported our thesis as to the effect of moisture in enabling the growth of rain-forests in comparatively cool surroundings, but it did not go as far as we wished because, as will be seen from the accompanying table of temperatures (kindly provided by Dr. Brooks) for the town of Livingstone close to the Falls, the mean annual temperature is as high as 72° F. But a mean annual temperature of 72° F. is higher than Dr. Brooks would accept as a possible one in latitude 52°. Nevertheless it must be remembered that the data are those of Livingstone, not of the forest itself, and we shall see later that there is the possibility that the two do not agree.

TABLE OF TEMPERATURES FOR LIVINGSTONE, NEAR THE VICTORIA FALLS

	November.	July.	Year.
	° F.	° F.	° F.
Mean daily maximum ..	94·2	76·7	85·5
Mean daily minimum ..	68·6	44·9	59·5
Mean temperature	81·4	60·8	72·5

" The highest recorded temperature (1922–1929) was 106° F. and the lowest 34° F."

It was plain that our difficulties were not solved and that our inquiry must be carried further. It was, therefore, with the whole question as to what are the limiting conditions for the growth of tropical rain-forests in our minds, that we explained our problem to those botanical friends at Kew who were conversant with tropical rain-forests in many parts of the world.

We found a universal opinion that these forests will always overpass, both in latitude and altitude, the limits of strictly tropical temperatures when moisture conditions are suitable. Thus Mr. J. Hutchinson pointed to the patches of rain-forest which appear from point to point on the eastern mountain ranges of South Africa from the Drakensberg to the south of Cape Colony, under favourable conditions of rainfall. Mr. C. Fischer pointed to the western edge of the Nilgiri Hills with a rainfall of 102 inches, as compared with a rainfall of 50 inches at Ootacamund. Of this western edge at an elevation of 6,000 feet (noting that the annual mean temperature at 7,000 feet is reported to be 57° F.) he informs us that "The original forest has a distinctly tropical or sub-tropical character. There are many genera which are distinctly tropical, though of course the species present are usually mountain forms." All botanists with tropical experience were agreed that tropical rain-forests extend their range upward in moist and sheltered ravines considerably beyond the range in the surrounding open country. Also all were agreed that moisture was the chief factor inducing such extension.

Nevertheless, although such was the received opinion, it was not possible to obtain any precise data. We were told of rain-forests at altitudes where it felt quite cold, "as if it were freezing, although of course it was not really freezing, perhaps about 40° F." But no one could give us definite observations, because they had not been made.

When we sought for published information we found this was very scanty, and there were no precise data, although one or two writers refer to the effect of moisture in developing rain-forest growth at extra-tropical elevations. Writing of the rain-forests in Jamaica, above the height of 4,500 feet, which in general show the character "of temperate forests rather than of those in tropical lowlands," Mr. Forrest Shreve (1914, p. 27) states, "the ravines and valley bottoms and their adjacent slopes will be shown to be the most hygrophilous habitats in the rain-forests; particularly on the windward slope they show a wealth of luxuriance which rivals that of the lowland forest." And of Madagascar Dr. C. Keller states (1901, p. 38): "When we pass the belt of forest and reach the high land of the interior, the character of the vegetation becomes quite different. It is true that in some of the numerous glens a luxuriant tropical vegetation is still to be found, but as a whole the interior is treeless."

In a general way the evidence supported the terms of our inquiry but, like most of the verbal information, it contained no precise meteorological data in regard to the rain-forests, and we were at a loss where to obtain any. The reason for the difficulty was explained by the late T. F. Chipp, then Assistant Director of Kew Gardens. He pointed out that meteorological stations are always placed in clearings. Even if they should happen to be situated within the bounds of a tropical forest, the forest is always cleared around them. Consequently no true forest records are obtainable. He further expressed his belief that when these were obtained they would show that a considerably lower temperature prevailed in the forest than in the clearings. Like other botanists with great tropical experience, Dr. Chipp also held that moisture can over-ride temperature in inducing rain-forest growth. In his "Ideal Climate Chart for the closed Forest Climax" (1927, fig. 19) the conditions assigned for this growth are, "abatement of rains in August, equable temperature, high and constant relative humidity."

At this point Dr. Chipp and Dr. W. B. Turrill led us on to a further stage in our inquiry, a stage which we had not ourselves envisaged. by stating that in their opinion it is not merely a question of moisture and temperature, but of a general balance between a whole complex of conditions of which moisture and temperature are but the two most important. And Dr. Chipp expressed his firm opinion that, regarding tropical rain-forests, virtually nothing is known as to what these conditions may be.

That Dr. Chipp was justified in his opinions as to the want of knowledge of the true conditions of rain-forest growth is shown by the following table of data kindly obtained for us by Mr. A. D. Cotton, the keeper of Kew Herbarium, from Mr. W. Nowell, the Director of the East African Research Station at Amani, Tanga, Tanganyika Territory, and by Mr. Nowell's covering letter to Mr. Cotton. Mr. Nowell writes: " You will think I am a long time replying to your letter of the 28th of January asking for temperatures in rain forest. The reason is simple: we could not find any such records and have had to make them. The observations are being continued by Moreau for his bird ecology work." With regard to these observations it is stated in a communication appended and signed R.E.M.: " The 2 sets of records are taken at points 110 yards apart and the instruments are interchanged weekly. It is to be noted that except for the first week the records relate to a period of heavy rain when the general conditions were abnormally stable. At other seasons daily ranges up to 30° F. have been recorded at the main Amani Station: absolute max. and minima 89° F. and under 50° F. I do not think the forest max. and min. would ever be much above 75° and below 60°, with a maximum daily range of perhaps 12° F.

" In the microclimate of the forest I should expect the low light-intensity to be quite as important from the biological point of view as the T/H. The average light intensity on the floor of the forest is of the order of 1% of the light in a clearing quite free of shade."

A further note is appended stating: " The records are made in a Stevenson screen. One set of instruments in the forest, the other in an adjacent clearing."

The table is as follows:

Week ended Monday.	Temperature (° F.).						Humidity.						
	Absolute maxima.		Absolute minima.		Maximum daily range.		Absolute maxima.		Absolute minima.		Maximum daily range.		
	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.	
April 27..	75	82	64	62	11	20	92	92	68	50	23	40	
May 4 ..	72	82	62	64	10	18	91	92	69	62	22	28	Over this period rainfall averaged 0·8 inch a day.
May 11 ..	71	77	66	62	5	15	92	92	74	57	17	33	
May 18 ..	69	76	62	65	6	10	91	93	71	64	19	29	
May 25 ..	67	71	64	62	3	7	92	92	?	70	?	22	
June 1 ..	68	75	61	64	6	11	91	92	67	63	23	29	

So far as we have been able to discover, the only important attempt that has been made to investigate scientifically the natural causes which limit the spread of various types of vegetation, including the vegetation of the moist tropics, is that by Messrs. Livingston and Shreve published under the title " The Distribution of Vegetation in the United States as related to Climatic Conditions " (1921). They point out (p. 149) that, " The information so far accumulated upon environmental conditions has not been obtained primarily with reference to plant activities ; it has been brought together mainly in the interest of meteorology, climatology, and weather prediction. Therefore it is impossible at present generally to select for study those conditions that directly affect the plant. We have been forced in the main to study conditions or factors that are more or less remote causes of the immediate conditions affecting plants. This is not always the case for the air temperature of the climatologist and meteorologist is the temperature condition of the aerial environment of organisms, and the evaporating power of the air is a factor that directly affects the rate of water-loss from the aerial parts of plants." The authors share a very similar view to that taken by Dr. Chipp and Dr. Turrill, that it is a whole complex of climatological factors interacting with physiological factors in the plant which decide what are the limiting conditions which determine the existence of various types of plant life (*op. cit.* pp. 113–148) and state (p. 148) that " *No plant has ever yet been studied with even approximate control of all the influential conditions* of its surroundings " [Livingston and Shreve's italics] ; and again (p. 150) : " The subterranean environment of plants has not, as yet, been studied in any way at all adequate to the present purpose."

It is not, therefore, surprising that we were unable to obtain much definite information of the type we needed. The best evidence as to the possible nature of the London Clay climate, we have obtained from the statistical tables published by the authors quoted above. In these tables Messrs. Livingston and Shreve give valuable information regarding the tropical regions of the United States, and the conditions under which the tropical flora as a whole grows in the United States, including information as to the lowest mean temperature which will support the flora. They give similar information regarding the environmental conditions of two palms, *Sabal palmetto* and *Serenoa serrulata*, belonging to genera which we have recorded from the London Clay forest. At the present day the two palms inhabit country with a mean annual temperature varying from 65° to 75°, whereas the strictly tropical flora inhabits country with a mean annual temperature varying from 70° to 75°. It is possible, therefore, to form some idea as to what may have been the climatic conditions which supported the growth of the tropical London Clay forest. We emphasize the word " tropical " because it must be remembered that there is reason to think that *Sabal* represents one of the cooler elements in the London Clay flora (p. 60). So, probably, does *Serenoa*, since the living palms share almost precisely the same environment in the present day. The climate, therefore, of the London Clay cannot be based on the coolest limit of the temperature range of these two plants, but more probably might compare with the lowest range of the tropical flora.

It is unnecessary to quote Messrs. Livingston and Shreve's tables at length because the gist of their information, so far as our present purpose is concerned, is contained in the following passage as to the habitat of *Serenoa serrulata*: " Only the extreme edge of the Atlantic Coastal Plain is occupied by this palm, from South Carolina to the eastern border of Texas. It occupies the warmest and moistest portions of the area which has just been stated to be favourable for the development of evergreen broad-leaved trees with which it may be classed. Considering the small area occupied by *Serenoa,* it encounters a wide range of conditions in both temperature and precipitation, together with narrow range of evaporation, humidity and the moisture ratios. It encounters a frostless season of 231 days or more and no cold days in our sense. Its limit coincides closely with the line of 50° for the normal mean temperature of the coldest 14 days of the year, although the palm does not follow the region of these temperature conditions into southern Texas. The encountering of the conditions expressed by a moisture ratio of 1·00 appears to be responsible for the westward limitation of a plant which is elsewhere controlled by temperature conditions " (*op. cit.* p. 549). Thus, again, we meet with moisture as the ultimate controlling factor rather than temperature in the westward spread of *Serenoa serrulata,* although in this case it is not a low temperature that is in question, as it is in the London Clay.

From the above facts it appears possible that, given suitable conditions of precipitation, of the balance between precipitation and evaporation, of the seasonal distribution of the rainfall, of a very equable climate, and a frostless winter, the London Clay flora might have lived under a mean annual temperature of about 70° F. It might have been a little lower, but this is a mere matter of speculation. We have no sufficient data at present to guide us. But it may be found, when research has been made as to the minimum temperature conditions of rain-forest growth, that such may prove to be a possibility.

Meantime when we return to the original inquiry which has evoked this long discussion of the conditions of rain-forest growth, namely, the question whether Dr. Brooks' hypothesis could postulate a climate that would suffice for the growth of a tropical rain-forest of the type suggested by the London Clay genera, we find that he and we are in fairly close agreement. Whether we can actually be said to have met is perhaps a question for further research on the lines we have indicated in regard to rain-forests. When we informed Dr. Brooks of the conclusions to which our investigations had led us, he replied : " It is, of course, impossible to give exact figures for past temperatures, and though I think a mean annual temperature of 70° rather high for latitude 52°, I can not say it is impossible. The frostless winters are easier ; I should have said from geographical considerations alone that frost was improbable in south England in the London Clay period."

(*b*) **The Gradual Cooling of the Climate in Succeeding Tertiary Times.**—We must next inquire how the hypothesis will account for the cooling climate of the later Tertiaries from the end of the Eocene onwards. We take it that Dr. Brooks' explanation would be somewhat as follows (Brooks, 1925, chap. iii ; and Brooks, 1925*a*) : The period of the highest transgression of the Tethys Sea in the Middle Eocene, when the climate of Europe was hottest, was succeeded, towards the end of the Eocene or beginning of the Oligocene, by a period of earth-movement and mountain building during which the great trans-continental mountain-chains of Eurasia came into being. These earth-movements, by blocking the eastern and northern outlets, transformed the Tethys Sea into a land-locked Mediterranean ; a very immense Mediterranean, it is true, penetrating far inland to the north both in France and Central Europe, and one which for a long period seems to have exerted an ameliorating effect on the west European climate, keeping it warm and humid. Nevertheless the inflow of tropical waters was checked, and warm currents no longer reached either the shores of west Europe, or the Arctic Ocean. Hence sea-ice would begin to form at the North Pole. This in its turn would lower the temperature of the surrounding regions, at first by conduction, later by atmospheric circulation also, so that an ocean covered by sea-ice would replace the ice-free Eocene Arctic ocean. At the same time changes of level were taking place both on land and beneath the sea. Towards the close of the Tertiary period the Behring Strait became shallow and narrow, the Atlantic became partially blocked by a ridge between Iceland and Scotland ; both changes resulting in a check to the outflow of cold water from the Arctic Ocean. Together with these changes, much of the circumpolar land was elevated in Europe, Asia, and America, in some parts very greatly. Thus not only did the circumpolar land increase in area, but it was raised in altitude, with the result that it became colder, forming the source from which cold rivers discharged themselves into the Arctic Ocean, yet further lowering its temperature. The resulting fall of temperature accruing from all these changes caused a further extension of the sea-ice and the formation of glaciers and land-ice, resulting ultimately in the formation of a north-polar ice-cap of enormous extent, and the development of the Great Ice Age in the Northern Hemisphere.

It is evident that if the palaeogeographical changes—all of them very generally accepted by geologists—will suffice to produce the effects which Dr. Brooks ascribes to them, the results from the Middle Tertiary onward to the Pleistocene period would be in close agreement with the changes of climate indicated by our Diagrams of Distribution ; but of the meteorological arguments we are unable to judge. Also we are not concerned to follow the subject into the later question of Pleistocene climates.

(*c*) **The Present Distribution of Tertiary Relic Floras.**—For the third of our demands that the Far East must have been within easier range for the migration of plants than America, the hypothesis of Dr. Brooks provides a much more satisfactory solution than that of Professor Wegener, for Dr. Brooks demands the permanence of the North Atlantic as one of the great waterways for the northward flow of warm water into the Arctic Ocean. Such a break in the circumpolar ring of land would well explain the closer affinity of the European Tertiary floras with the present east Asian flora than with the North American flora, provided that the hypothesis of southward migration of circumpolar floras during the later Tertiaries be accepted ; because the gap formed by the broad Atlantic between Europe and America would, presumably, form a greater obstacle for the migration of plant life than would the narrow Obic Sea, across the southern opening of which a hot current swept Europewards and carried the life of Indo-Malaya to Europe during the London Clay–Bracklesham period, whereas later, the continuity of the Eurasian continent was only interrupted by isolated lakes and seas, of which the Caspian Sea and Sea of Aral are some of the remains.

(*d*) **Approximately Stable Poles.**—Dr. Brooks' hypothesis requires stable poles, which is the fourth demand we made to account for the distribution of the Tertiary relic floras.

(*e*) **The Dominance of the Indo-Malayan Element in the London Clay Flora.**—Dr. Brooks' hypothesis affords an admirable explanation of the dominance of the Indo-Malayan element in the London Clay flora. For just as he finds in the Tethys Sea the primary cause of the hot Eocene climate, so we find, in the same sea, the cause which decided that the flora should be predominantly of Indo-Malayan type. Its northern shores furnished the pathway from Indo-Malaya to west Europe; whilst, at the same time, its waters barred the way for any great inflow of African genera, and the Atlantic presented an even more efficient barrier against the entry of American genera.

Hence we are of opinion that Dr. Brooks' hypothesis, based on the facts of physiographical changes in the Tertiary period, probably explains correctly the causes of the hot Eocene climate in west Europe and of the ensuing cooling which occurred during the later Tertiaries; and, in consequence, the fundamental cause which led to the peculiar types of successive fossil floras in west Europe and the present distribution of the relic floras. There may, or there may not, be some small discrepancy between the climate postulated by Dr. Brooks for the London Clay and Bracklesham periods and that which the floras of those periods seem to demand as a minimum for their growth. This discrepancy is probably due to our incomplete knowledge regarding the minimum temperature conditions which will support a tropical rain-forest flora.

VII. THE RELATION OF THE LONDON CLAY FLORA TO OTHER EOCENE FLORAS OF SIMILAR AGE

It is extremely difficult to compare the London Clay flora with other fossil floras for more than one reason.

In the first place, with the exception of a few species in a few deposits, all European Eocene floras have been determined from leaves, whereas the London Clay flora has been determined from fruits and seeds. In a previous work (Reid & Chandler, 1926, pp. 12, 13) we showed that there were reasons why the contents of seed and leaf beds respectively would probably not represent the same plants. It was pointed out that selective processes were at work which, from the very beginning of the journey of the various floral relics to their ultimate place of deposition, must tend to separate the two kinds of organs, and lead to the presence in fruit and seed deposits of different genera from those found in contemporaneous, and possibly adjacent, leaf deposits. The selection is due to the different adaptability of the fossil relics for transport by the various agencies at work: wind, rain, animals, and so forth. Leaves may be blown long distances into the water, whereas the fruits and seeds of the same trees, unless adapted for special forms of transport, must fall beside the parent plant. Or, again, fruits and seeds may be carried very far from the parent in the fur or feathers or on the feet of animals; much farther than wind or rain can carry the leaves. We have already quoted (pp. 20, 21) Moseley's observations of the separation between leaves and fruits in the sea and river drift off the mouth of the Ambernoh River of New Guinea. Siftings such as these must very naturally result in differences between many of the genera represented in the two types of deposits. In consequence we are met at the outset of the inquiry by a fundamental want of correspondence between the two types of floral relics which makes it difficult to compare them. The best mode of comparison would be that of the geographical distribution of the relic genera. Whatever these might be, the geographical distribution of the living representatives should correspond in a general way. The present work suggests that in order to compare the relative ages of the London Clay and of other floras of Tertiary age, it would be best to examine in what degree they are tropical and show Indo-Malayan affinity. Yet when we attempt to apply the test we are met by a second difficulty, for much of the older work is published without that evidence of detailed research and comparison which admits of a confident acceptance of all its determinations. And we have not ourselves the requisite knowledge of leaf-structure to make an independent and critical estimate of these determinations. All we can say is that they do not offer sufficient terms for close comparison.

1. European Eocene Floras

The flora of the Calcaire Grossier of the Paris Basin has generally been regarded as of approximately the same age as the London Clay (Saporta, 1879, p. 224). In part it has a very tropical aspect, and several of the same genera are common to both deposits—*Sabal*, *Araucarites*, *Nipa*, *Apeibopsis* [*Oncoba* ?], *Magnolia*, *Cupania* [*Cupanoides*], and *Cinnamomum*. Many of the same families also occur—abundant Lauraceae, members of the Myrsinaceae, Sapotaceae, Anonaceae, Juglandaceae, and Myrtaceae. But with these, if the lists are to be trusted, is a very considerable intermingling of purely temperate genera—*Betula*, *Alnus*, *Populus*, *Salix*, *Corylus*, *Carpinus*, *Andromeda*, *Acer*, and *Pyrus*. Consequently the correspondence cannot be said to be very close. We should not have expected quite such a large temperate element in a contemporaneous flora, unless it could be shown that there were high mountains in the watershed. At the same time we know that Saporta recognized the affinity of the hotter part of the flora with the living floras of Indo-Malaya and Africa (1879, pp. 223, 228).

Again, the Sarthe flora (Crié, 1878) is of a more uniformly warm type, although *Nipa* is not recorded. But we find *Sabal* and other palms, *Araucarites*, *Oncoba* (?), ("*Apeibopsis* Heer"), also Lauraceae, Apocynaceae, Myrsinaceae, Celastraceae and Anacardiaceae; and the cooler types, except *Andromeda*, are absent. Yet the Sarthe flora is regarded by Crié, Hébert, and Saporta, upon palaeobotanical grounds, as of Bartonian age, contemporary with the sands of Beauchamp.

Such facts as these make it extremely difficult to determine whether other floras represent hotter or cooler conditions; or, upon palaeobotanical evidence alone, to discover what is the relation of the floras to one another botanically, geologically, or climatologically.

Except stratigraphically we have as little knowledge of the relationship of the London Clay flora to most of the Eocene floras of England as to those of the Continent. The Alum Bay flora, which probably is tropical, has never been worked out in any degree satisfactorily. Our knowledge depends almost entirely on a short list of species with scanty notes by La Harpe (1862, pp. 109–120, pls. 5–7), who compared it with the London Clay flora. But his work shows almost no correspondence with our own, so that it offers no useful terms of comparison. The imposing list of Alum Bay species by Ettingshausen (1880), unsupported by evidence, can no more be regarded as trustworthy than his Sheppey list. Gardner's Eocene work, again, has not proved to be very accurate so far as we have tested it, and was not documented beyond the Gymnosperms. All the scattered references he makes to Phanerogams as occurring in the Alum Bay and Bournemouth Beds are without descriptions or adequate illustrations, and must be accepted with great caution. He makes the statement (1889*a*, pp. 105, 106) that the Alum Bay flora "is the most tropical of any that has so far been studied in the Northern Hemisphere." Very probably it is; but there is no published evidence, except a bare provisional list, that warrants the statement. Nevertheless Gardner was careful to add that "in the present state of our knowledge no real analysis of the Alum Bay flora is possible."

With regard to the study of the Bournemouth flora, besides Gardner's work there is that of Dr. Helena Bandulska. She has made careful and detailed studies of some of the leaves. Her cuticular studies have led to the determination of *Araucarites*, *Sequoia*, *Taxodium*, *Aniba*, *Neolitsea*, *Litsea*, *Lindera*, *Cinnamomum*, *Nothofagus*, *Rhodomyrtus*, and *Tristania* (1923, 1924, 1926, 1928, 1931). It is known, moreover, that the fruits of *Nipa* are plentiful (Gardner, 1879, p. 221). There appears to be a more important American element than is found in the London Clay, but the occurrence of so many tropical Lauraceae of east Asian type, also *Rhodomyrtus*, suggests a flora of similar derivation. The latter living genus is represented by a close relation in the London Clay; and it may be noted that it was also found in the little flora of St. Tudy (Finistère) of supposed Eocene age (Reid, E. M., 1930); a flora not quite so tropical as that of the London Clay, but showing a very similar Indo-Malayan affinity.

The above illustrations of the difficulties in the way of comparison will show that it is not possible to compare the London Clay flora with other Eocene floras very effectively, nor in the present state of our knowledge to estimate on purely botanical evidence their relative ages. We think there may be a reason for this. For, if we are right in finding with Dr. Brooks the cause of the hot Lower and Middle Eocene climate of Europe and the presence of the Indo-Malayan flora in west Europe, in the northward extension of the Tethys Sea and its connexion with the Indian Ocean, then, just so long as this connexion and the great transgression of the sea lasted, so long would the west European floras be likely to retain a tropical character and a close connexion with the Indo-Malayan and African floras. In consequence it might be difficult to recognize the exact stage in this relationship when stratigraphical evidence is wanting. Very similar floras might belong to periods anterior and posterior to the duration of the greatest heat. Also, during the continuance of the great heat, similar but not contemporaneous floras might have existed. To us it suggests that very great care is needed in order to determine the exact position of Lower and Middle Eocene deposits on purely palaeobotanical evidence. If in the future it is possible to make detailed studies of other Eocene and Palaeocene horizons in the south of England where the stratigraphical relationship is fairly simple, the relation of these floras may become clearer.

In connexion with the change in floral relationship anterior to the London Clay period and a reverse change later in the Eocene—perhaps after the Bracklesham—we may note that Gardner observed both breaks, although he was probably wrong in placing the later break between the Alum Bay and Bournemouth Beds. It was probably more recent. He remarked (1889*a*, p. 106): "The break between the London Clay flora and those which preceded it is very great, and obviously due to a considerable increase of temperature. The connexion between that of Sheppey and of Alum Bay, though probably a good deal over-estimated, is likewise due, it appears, to the high temperature having been maintained, bringing in a vegetation that had not been able to exist so far north since the close of the Cretaceous period; whence the Cretaceous aspect that has struck so many observers. The break, which is very great indeed, between the floras of Alum Bay and Bournemouth, deposited as they must have been under very similar conditions, is far less easy to explain. It is not altogether one of temperature, because there are still many large palms in the latter, as *Iriartea*, *Phoenix*, *Calamus*, *Nipa*, with decidedly sub-tropical ferns. Some break or change must have driven the indigenous flora almost completely away and brought in the new set of plants which maintained themselves and spread over central Europe, only dying out or giving way in late Miocene times." The details may be wrong, but Gardner divined that some cause (the transgression of the Tethys Sea and its connexion with the Indian Ocean, we say) brought in the new (Indo-Malayan) flora, maintained it for a period, and then when the cause was withdrawn (the regression of the Tethys Sea) its extinction followed. Our diagrams of distribution clearly point to a very great change in plant association as having occurred some time between the London Clay and the end of the Eocene, which resulted in the all but complete extinction in Britain of the highly tropical Indo-Malayan element. Only *Nipa*, *Iodes*, and *Tetrastigma* among the lowland Indo-Malayan plants of the London Clay are known to have survived until the end of the Eocene.

If it be the true explanation of the climatic problem before us, that the hot Eocene climate of west Europe was dependent upon the equatorial current carried by the Tethys Sea, then it would appear probable that the climate of countries far removed from its influence, but in approximately the same latitude, would differ very greatly from the climate of the sea-board countries. If so, then the true explanation of the differences noted by Professor Kryshtofovich between "the much warmer climate of Europe, and in contrast to it the slight change of climate (increased continentality) in north Asia," may be that west Europe and the Ukraine (which he classes with it) were the sea-board of a very warm sea; and that north Asia then, as now, was continental. Consequently the explanation he suggests that it is due "to the migration of the North Pole to the northern part of the Pacific, with corresponding changes in latitude of the countries under consideration; although in some degree these and other changes might be the result of displacement of either the whole or parts of the continental masses," is not required (1929, p. 311).

In connexion with this work by Professor Kryshtofovich we may express our satisfaction at the attempt he has made to delimit certain ancient botanical provinces. It is difficult to estimate the value of such an attempt based, as it is, on the very limited stock of information at present available, much of which, as he himself points out, is not altogether satisfactorily dated. Nevertheless we welcome the attempt for this, if for no other reason, that it must serve to impress on workers the necessity of keeping in mind the differences which are likely to occur between contemporaneous floras in different regions, and to check a uniformity of determination which sometimes appears to be forced.

We are now in a position to envisage a little more clearly the history of the Tertiary floras of Europe. It would seem to be closely linked with the history of the Tethys Sea. At the end of the Cretaceous period a warm flora inhabited west Europe which probably owed its establishment here to the Cretaceous transgression of the Tethys Sea. It was followed by a cooler Palaeocene flora at a time when the sea had regressed, and was "closed to southern (Tethyan) migrations" (Morley Davies, 1930, p. 311), although some genera, *Araucarites*, *Magnolia*, and others, lived on. When again the great transgression of the Tethys Sea and communication with the Indian Ocean occurred in the Lower Eocene, a tropical flora of very definite Indo-Malayan type established itself in west Europe, which flora is represented in the London Clay and the Bournemouth Beds. When later, towards the end of the Eocene, the connexion with the Indian Ocean was broken—this time never to be re-established—cooler plants took the place of the more tropical ones. Some of these may have survived from the Palaeocene in whatever mountains there may then have been in west Europe, some in more northerly regions. Yet others were entirely newcomers, probably also from the north. The great tide of migration had turned. Henceforth until well into the Pleistocene, possibly with a few slight abatements, it was to flow southward in latitude, downward in altitude; ever cooler and cooler floras succeeding one another. When during Interglacial periods the tide once again turned, it was from the south of Europe that the warmer immigrants came. It is the clear evidence of alternate southward and northward, downward and upward migration as the climate changed in the Pleistocene (see p. 69), which makes us suggest that, in very broad outline, this was the course of Tertiary plant life in west Europe. Such a view helps to explain a phenomenon spoken of by Saporta, "un phénomène des plus curieux, celui de la 'recurrence' qui amène la réapparition par une sorte de retour périodique . . . des formes végètales." He partly realized the true cause. The species (often indicating a peculiar association of plants) were not destroyed and then recreated, but during the time of their apparent disappearance they had been located in places where no fossil deposits were formed to bear witness to their existence (Saporta, 1879, pp. 228–230), or perhaps in places where the deposits, if formed, have never been discovered or studied. It seems possible that if once again the old waterways between the Indian Ocean, the Arctic Ocean, and west Europe were to be reopened as in the Cretaceous and London Clay periods, and the warm climate of those days were to return, *Nipa* and *Dracontomelon*, the palms and Lauraceae, and many other of the inhabitants of the Indo-Malayan rain-forests might again people our shores. The genera would in most cases be different; the species in every case would be so. There would be on a grand scale one of those periods of " recurrence " of which Saporta speaks.

2. American Eocene Floras

In the foregoing we have dealt only with the relation of the London Clay to some European Eocene floras, and with the probable course of events which dominated their history. But we must not overlook the fact that interwoven with the history of European floras is that of American floras. For the first links we must doubtless look far back in the Cretaceous period, or perhaps even earlier. Already in the Cretaceous period genera which have American as well as east Asian affinity were established in Europe, and many of them continued even into the later Tertiaries. Into the question of the manner of this early connexion we are not prepared to go. It lies in a past beyond the range of our studies. But there seems also to have been a later and more intimate connexion in the Pliocene, marked by the appearance not only of American genera but American species also. For example, the genera *Decodon*, *Proserpinaca*, and the living American species *Liriodendron tulipifera*, *Nyssa sylvatica*, *Menispermum canadense*, and *Dulichium spathaceum*. Such occurrences seem to owe their introduction to a circumpolar flora. But it must be remembered that even a circumpolar flora may have some of its roots in the far past and depend, in part, for its origin on ancient migrations.

Like the European Eocene floras, nearly all those of America have been determined from leaves. It will readily be understood therefore that the terms of comparison with the London Clay flora are even fewer than in the case of the European floras, and that no useful purpose can be served by attempting such a comparison. Nevertheless there is one flora, the Brandon lignite of Vermont, to which we must make reference. This flora is represented by fruits and seeds as well as wood. There is no stratigraphical evidence to show its exact age. It is underlaid by Cambrian and overlaid by Quaternary deposits. On palaeobotanical grounds it was placed by Lesquereux (1861), Knowlton (1902), and Perkins (1905) in the Miocene. But at the same time, referring to the last edition of Dana's Manual, Perkins states that it was there said to be " probably of Eocene origin." He also states " that only a small portion of the fossils can be placed in modern genera with any certainty." If that is the case, and we think it probable, judging by the illustrations, the Brandon lignite must definitely be older than the Miocene.

Professor E. W. Berry (1919, p. 211) gives it as his opinion that the lignite may perhaps be Oligocene, as American Oligocene floras are but little known, but that it is most likely Eocene. He confirmed this opinion as to the Eocene age in a letter dated March 5, 1930, in which he states "that there can be scarcely a doubt but that the Brandon deposit is Eocene." The illustrations of Perkins' work suggest that the following should be referred to *Nyssa* or some closely allied genus: *Carpolithes* (1904, pl. lxxv, figs. 1–20) and *Glossocarpellites* (1905, pl. lxxxvi, fig. 15; 1906, pl. liv, figs. 1–3). Some of the *Tricarpellites* are probably *Canarium* or a nearly related genus, but they do not seem to be *Tricarpellites* Bowb. We do not think the published evidence justifies the determination either of *Juglans* or of many of the species referred to *Nyssa*. *Apeibopsis* may be *Apeibopsis* Heer, but is not *Cucumites* Bowerbank which Heer united with his genus *Apeibopsis*. *Cucumites Lesquereuxii* Knowlton (Perkins, 1904, text-fig. viii, nos. 3–5) is not *Cucumites* Bowerbank, as evidenced by Knowlton's cross-section. *Aristolochia* and *Cinnamomum* are very doubtful determinations and are not supported by any descriptive evidence; but the presence of some species of the Lauraceae is evidenced by the wood *Laurinoxylon* (Jeffrey and Chrysler, 1906). *Illicium lignitum* Lesq. (Perkins, 1904, pl. lxxx, figs. 146, 147) and *Drupa rhabdosperma* (pl. lxxxi, figs. 168–170) are probably Rutaceae. There appears to be an unnecessary multiplication of species, especially in the case of *Nyssa*. In conclusion: There may be some relationship, of what degree we can form no opinion, between two or three of the genera found in the London Clay and Brandon lignite, but the illustrations make it clear that the species are remarkably different. Especially do they differ in the much greater size of the Brandon fruits. We do not think they offer any valuable grounds for correlation.

Thus it does not appear possible to make a close comparison between the Eocene flora of America and that of the London Clay. The comparisons could scarcely go beyond the families represented.

VIII. SUMMARY OF CONCLUSIONS REGARDING THE FLORA AND CLIMATE OF THE LONDON CLAY

(1) The London Clay flora was mainly of a tropical rain-forest type, allied principally with the living Indo-Malayan flora.

(2) It reached Britain by way of the shores of the Tethys Sea, as proved by the occurrence of *Nipa*.

(3) In the Anglo-Belgian basin it was living at its northernmost range, since *Nipa* is not known further north.

(4) It was enabled thus to live because exceptional climatic conditions allowed it to overstep its norm of temperature.

(5) The most important of these conditions probably were: great precipitation, a suitable balance between precipitation and evaporation, a suitable seasonal distribution of rainfall, a uniform climate, and frostless winters.

(6) The conclusions (4) and (5) are based on observed facts in regard to the occurrence of tropical rain-forests in the present, and on the further observed fact

that the measure of climate in terms of plant life, does not coincide exactly with the measure of climate by temperature.

(7) In terms of temperature the London Clay climate would lie at the lowest limit for tropical plant life, probably a mean annual temperature of about 70° F.

(8) Professor Wegener's hypothesis fails to account for the facts of Tertiary history, because it leads to an incongruity when confronted with the facts concerning the distribution of the nearest living representatives of the west European Tertiary floras, and because it requires a shifting pole.

(9) Dr. C. E. P. Brooks' hypothesis with the aid of Dr. Simpson's hypothesis of change in solar radiation, will account for the hot Eocene climate, either completely or within narrow limits of error. It will also account for the cooling climate between the Middle Eocene and the end of the Pliocene, for the closer association of the Tertiary flora of west Europe with the living flora of eastern Asia than with that of America; and it demands the stability of the poles. Furthermore, it is based on the transgression of the Tethys Sea which carried the equatorial current of the Indian Ocean to the shores of west Europe, which is, in the authors' opinion, the cause of the ancient London Clay flora, of Indo-Malayan type, having established itself in or about latitude 50° N.

(10) The terms are at present too few to admit of very effective comparison between the London Clay flora and other European Tertiary floras. The same is true in even a greater degree of American Eocene floras.

THE COLLECTIONS

In the systematic part of the Catalogue, the provenance of the specimens is indicated in abbreviated form in the case of the main collections :

Bowerbank Coll.	J. S. Bowerbank Collection, purchased 1865.
Reid & Chandler Coll. ..	Collected and presented by Mrs. E. M. Reid and Miss M. E. J. Chandler, 1928–1929.
D. J. Jenkins Coll. ..	Collected and presented by Mr. D. J. Jenkins, 1928–1932.

The following are represented by a comparatively small number of specimens :

J. Brown Coll.	Collected by John Brown of Stanway, presented by Sir R. Owen, 1860.
A. G. Davis Coll.	Collected and presented by Mr. A. G. Davis, 1932.
W. Griffiths Coll.	Purchased 1860.
Mantell Coll.	G. A. Mantell Collection, purchased 1839.
Toulmin Smith Coll. ..	Purchased 1869.
H. A. Toombs Coll. ..	Collected and presented by Mr. H. A. Toombs, 1931–1932.
E. M. Venables Coll. ..	Collected and presented by Mr. E. M. Venables, 1929.

A few specimens were also acquired in the collections of S. H. Beckles, Caleb Evans, J. Starkie Gardner, G. J. Hinde, G. W. Shrubsole, W. H. Shrubsole, and J. Wright.

SYSTEMATIC DESCRIPTION

Thallophyta

DIATOMEAE

To W. H. Shrubsole belongs the credit of first recognizing Diatomeae in the London Clay of Southend, Sheppey, and the neighbourhood of London. He, in conjunction with F. Kitton (1881, pp. 381–387, pl. v), described eighteen genera, of which *Coscinodiscus* was by far the most numerous. No further work on this subject has been carried out, and for details of research and lists of determinations readers must be referred to the original paper.

In 1928 Mr. A. G. Davis (p. 344) recorded diatoms from the London Clay of Clapham.

V. 13686 Two slides of diatoms from Sheppey. *G. J. Hinde Coll., presented,* 1918.
V. 21364 Slide of diatoms (no locality stated). *Shrubsole Coll., purchased of F. H. Butler,* 1887.
V. 21365–67 Three slides (no locality stated). *Presented by G. W. Shrubsole,* 1931.

Charophyta

Genus CHARA (Vaillant) Linnaeus

1753. Spec. Pl., ed. 1, p. 1156.

Chara medicaginula (Lamarck) Brongniart

(For synonymy, *see* Groves in Reid & Chandler, 1926, p. 167.)

REMARKS.—Fruits of *Chara* were discovered in the London Clay of Copenhagen Fields, Islington, by John Purdue, at a time when a railway cutting was being made. About a dozen specimens, associated with thousands of Foraminifera, were obtained by washing the clay. They were recorded by T. R. Jones (1874, p. 479), who distinguished two species, one of which he compared with *C. helicteres* and the other with *C. Lyellii*. These specimens are now in the British Museum (Nat. Hist.), and were kindly examined for us by the late James Groves, who agreed that there are two distinct species, but was of opinion that the large globose fruits are *Chara medicaginula*, while the smaller ellipsoid fruits are not specifically determinable. *C. medicaginula* ranges from the Wealden to the Miocene.

V. 22131 Seven fruits. Copenhagen Fields, Islington. *Collected by J. Purdue, presented by Joseph Wright,* 1874.

Chara sp.

Remarks.—See above. Mr. Groves wrote: " I feel, after realizing the futility of so many of the determinations (with names) that have been made, that the setting up of fresh ' species ' upon the slender evidence of imperfect detached fruits, unless these represent some really distinct type, is of little use. The specimens of this second species belong to a common ellipsoid type and do not present any salient points of difference. The fruits measure about 800–875μ in length, 550–675μ in breadth, and the spiral-cells show 10–11 convolutions. As frequently happens in a gathering of Charophyte fruits, one of the specimens is evidently a dwarf individual."

V. 22132 Five fruits. Copenhagen Fields, Islington. *Collected by J. Purdue, presented by Joseph Wright*, 1874.

Gymnospermae

Order *CONIFERALES*

Family ARAUCARINEAE

Genus ARAUCARITES Presl.

1838. In Sternberg, Fl. d. Vorwelt, ii, p. 203.

Araucarites sp.

Plate I, figs. 1, 2.

1879. *Sequoia Bowerbankii* Ettingshausen (pars), p. 393.
1883. *Athrotaxis? subulata* Gardner, p. 43, pl. xi, figs. 2–14.

Description.—Coniferous twigs with spirally arranged (apparently heptastichous) imbricate falcate leaves, apparently of varying length, the free distal portion of the longest leaf on one twig measuring about 12 mm. On the opposite side of the same twig the leaves are shorter, from 6 to 8 mm. only. They are about 4 mm. broad at the base. The greater apparent length of one leaf may be due to those which overlapped it being broken away so that more of its length is exposed. Each leaf is slightly convex or angled on the lower surface and concave on the upper. The leaves of one twig in the Geological Survey Collection, London (48709), are distinctly more falcate, and more prominently keeled, than those above described.

On the lower surface of some of the leaves there are numerous close small ribs about 0·1 mm. apart. We are uncertain whether these are original; they may rather be due to preservation and abrasion, which have caused parallel rows of stomata to stand out as ridges. The surface is so worn that no stomata can be distinctly seen, but the surface cells show clearly in certain patches; they are roundly hexagonal, longer than broad, and longitudinally aligned, each being about 0·025 mm. long on the average.

An impression in pyrites of a small portion of the upper surface of a leaf (Pl. I, fig. 2) shows quite clearly that on that surface there are large stomata arranged symmetrically in longitudinal rows, and approximately in transverse rows also. We counted ten longitudinal rows in a width of 1·25 mm. (*i.e.* there is an interval of 0·14 mm. between the rows). The guard-cells of the stomata are aligned longitudinally. The surface cells on the upper surface cannot be traced clearly but they appear to be small. Length of best preserved fragment, 21 mm.; breadth, 10 mm. Length of longest specimen (48709, Geological Survey Collection), 60 mm.

Remarks.—One good apex of a twig partially carbonized, embedded in and impregnated with pyrites, has furnished most of the information given above (V. 22000, Pl. I, figs. 1, 2). A second small fragment, entirely pyritized, probably belongs to the same species, but is too badly preserved to be of value (V. 22002). A third fragment (V. 22001), also pyritized, is much abraded so that in parts the palisade layer is exposed in section at the edges of the leaves. The leaves are of the same shape and form as the shorter ones in the specimen first described; they show indications of the same striations and probably therefore of the same arrangement of stomata. There are also seven vertical rows of leaves in this twig. Two good twigs are preserved in the collections of the Geological Survey, London (nos. 48708, 48709), and a small specimen was found by the authors at Minster in 1929.

The specimens are of the type generally referred to *Araucarites*, *Sequoia*, or (by Gardner) to *Athrotaxis*. But the arrangement and character of the stomata, so far as they can be seen, are those of *Araucarites*, and serve to show that the twigs cannot be referred either to *Athrotaxis* or to *Sequoia*.

Affinities.—We have submitted photographs and a specimen of this conifer to Dr. Rudolf Florin for examination. He has kindly written to us as follows: "I think you are perfectly right in referring the coniferous twigs in question to *Araucarites*. I have read the description carefully and compared it with my experiences of recent Araucarias. . . . The Sheppey twigs seem to have belonged to the top of an older tree of a broad-leaved species of the section *Eutacta*; the photographs seem to show two types of leaves: one with more keeled lower surface and comparable with the adult leaves of *Araucaria excelsa* or *Cunninghamii* and another broader with more rounded lower surface as in *A. montana* and *columnaris*. The arrangement of the stomata shows also, in my opinion, that it cannot be either an *Athrotaxis* or a *Sequoia*."

A twig of *Araucarites* from Sheppey is figured by Parsons (1757, pl. xvi, fig. 23) as an "ear of corn or some species of grass." The same specimen is again drawn by Crow in his manuscript catalogue of Sheppey fossils (1810, no. 63) and described again as an "ear of corn." A twig is figured by Parkinson (1804, pl. vi, fig. 29).

Prestwich's record of *Lycopodites squamatus* Brongniart, in a list of Sheppey fossils (1854, p. 413), probably refers to *Araucarites*.

In 1879 Ettingshausen stated that "*Sequoia Bowerbankii*" was represented by fruits, seeds, and twigs. The only coniferous twigs found at Sheppey are those of *Araucarites* sp., described above, so that it must be these twigs which he regarded as *Sequoia*.

In 1883 J. S. Gardner described and figured similar fragments of coniferous twigs from Sheppey under the name *Athrotaxis* (?) *subulata* (p. 43, pl. xi, figs. 2–14). He states that the leaves are "spiral in eight rows, thick, scale-formed, closely inlaid, broadly triangular, falcate, keeled on the back, and concave on the inner face."

In regard to these specimens Professor Seward says (1919, p. 314): "Gardner also assigns some pieces of vegetative organs and in one case a cone to *Athrotaxis*, but the evidence on which the species *Athrotaxis* (?) *subulata* is founded has little value." But on p. 268 (*op. cit.*) he adds: "Some of the fragments of branches described by Gardner as *Athrotaxis* (?) *subulata* may well belong to *Araucarites*."

V. 22000 Figured Pl. I, figs. 1, 2. Twig showing impressions of stomata.
V. 22001 A fragment of a more slender twig.
V. 22002 A poorly preserved fragment of a twig. Heavily impregnated and incrusted with pyrites.
The above are all Bowerbank Coll., Sheppey.
V. 22003 Twig. *Reid & Chandler Coll.*, Minster, Sheppey, 1929.

Family ABIETINEAE

Genus PITYOSTROBUS Nathorst

1897. K. Svensk. Vet. Hand., XXX, p. 5.

Pityostrobus sp.

1879. ? *Pinus Sheppyensis* Ettingshausen, p. 393.
1884. *Pinus Bowerbankii* (Carruthers) Gardner, p. 68, pl. xiv, figs. 3, 8.

Two fragmentary cones, now decayed, were recorded and figured by Gardner from the London Clay of Sheppey. He states that they showed nothing of the size and external form of the cone and one only presented a few perfect scales. These scales were about 20 mm. broad, the axis of the cone was very stout, and was "marked deeply with pear-shaped scars and rather large and winged seeds."

Such a description furnishes no further evidence than do Gardner's figures for placing the specimens in the genus *Pinus*, and the evidence of the figures themselves can only be regarded as quite inadequate for his generic determination. On Gardner's own showing also, there is an "absence of any distinguishing specific characters." Yet in spite of this, and of his further statement that, "if Dixon's figure [of *P. Bowerbankii* Carruthers] were an absolutely reliable representation, it would be manifestly improper" to unite the Sheppey cones with Carruthers' species, he does so unite them. We cannot accept his determination and prefer to describe the cones as *Pityostrobus*, a name proposed by Nathorst for cones which do not show closer affinity to *Pinus* than to other genera of Abietineae.

Family TAXODINEAE

Genus SEQUOIA Endlicher

1847. Synops. Conif., p. 197.

Sequoia (?) *Shrubsolei* Gardner
[*Petrophiloides* sp. ?]

1886. *Sequoia Shrubsolei* Gardner, p. 91, fig. 35 on p. 92.

Under this name Gardner describes a cone 37 mm. long, and 20 mm. in diameter, which he refers to the genus *Sequoia*, giving it the specific name *S. Shrubsolei*. He states: "It is composed of about 40 scales, lozenge-shaped, or imperfectly hexagonal, measuring 10 millimetres across and 8 in height, becoming smaller towards the apex of the cone, and very slightly diminishing towards the base. *They are sunken in the middle, and have been considerably abraded.* The cone was embedded before the scales had gaped and still adheres to a stout footstalk 7 millimètres across. . . . *The fact that the scales are tightly closed, are preserved in pyrites* instead of lignite, that they had undergone compression, and that the petiole had a relative stoutness, all favour the assumption that the cone had not reached maturity when detached from the tree." [The italics are ours.]

Knowing the method of preservation most commonly found among Sheppey fossils, and especially knowing the mode of preservation in the strobils of *Petrophiloides Richardsonii* (p. 137), the above description at once suggested to us the similarity of this fossil to strobils of that species in a certain state of abrasion. In these strobils areas "sunken in the middle" and "considerably abraded" mark the position of the small fruits which are embedded in infiltrated masses of structureless pyrites forming the infilling between the cone scales. The scales, which are comparatively thin and are partially carbonized, are softer and more easily worn down than these masses of pyrites which, in transverse section, are approximately quadrilateral. Consequently the pyritized masses stand up as though they might be the actual scales "preserved in pyrites," whilst the true scales are scarcely visible except in sections of the cones. If this explanation be correct, this cone was in all probability not a cone of *Sequoia*, but a strobil of *Petrophiloides*, although we have seen no specimen of *P. Richardsonii* exactly corresponding with Gardner's description. Most are smaller, and have more numerous and smaller scales; nevertheless we have seen some specimens even larger (one measuring 42 mm. in length), and other specimens with only eight scales in a whorl. Gardner's specimen of "*Sequoia*" seems to have had nine or ten.

As against such an interpretation it must be remembered that Gardner himself first recognized the highly characteristic method of preservation common in *P. Richardsonii* in which the pyrites infilling between the scales forms hard quadrilateral or lozenge-shaped areas in the midst of which are embedded the fruits (seeds as he wrongly called them, when he mistakenly described *P. Richardsonii* as an *Alnus*). It is just possible that he had never seen a strobil of *P. Richardsonii* in precisely this state of preservation with the lozenges of pyrites almost masking the presence of the scales and fruits, although a specimen in much the same state is figured by Bowerbank (1840, pl. x, fig. 7).

The specimen was sent from Sheerness by W. H. Shrubsole and is no longer extant.

Family CUPRESSINEAE

Genus CUPRESSINITES Bowerbank

1840. Foss. Fruits and Seeds of London Clay, p. 51.

Diagnosis.—Woody cones belonging to the family Cupressineae, of which the nearer relationship to living genera cannot be determined. *Cupressinites* is therefore a form-genus. Hence the species referred to it need not necessarily be related generically.

Discussion.—Bowerbank established the genus *Cupressinites* to include a number of fruits which he regarded as allied to the Cupressineae. Many of these must now be referred definitely to other families. Thus *C. globosus*, *C. elongatus*, and *C. recurvatus* belong to the Lauraceae (see *Crowella globosa*, p. 216); *C. subfusiformis* is an angiospermous fruit of unknown affinities (see *Carpolithus subfusiformis*, p. 499); *C. crassus* appears to have belonged to the Juglandaceae (see *Juglandicarya crassa*, p. 145); *C. subangulatus* must be referred to the Myrtaceae (see *Palaeorhodomyrtus subangulata*, p. 436); *C. sulcatus* and *C. semiplotus* belong to the Meliaceae (see *Toona sulcata*, p. 276); *C. tessellatus* is in part a concretion (Bowerbank, 1840, pl. x, figs. 30, 31) and in part (pl. x, figs. 26, 27) appears to be an angiospermous fruit of unknown affinity (see *Carpolithus tessellatus*, p. 501); but since the type represented by the figs. 26, 27 is wanting, it is not possible to determine the relationship more closely. *C. corrugatus* also appears to be the fruit of an angiosperm. A discussion of its possible relationship will be found under "*? Tamesicarpum polyspermum*" (p. 423).

There remain *C. thujoides*, *C. Comptonii*, and *C. curtus*, and these alone of Bowerbank's species can be retained in his genus *Cupressinites*. In our opinion they should probably be referred to a single species.

Cupressinites curtus Bowerbank

Plate I, figs. 3, 4.

1840. *Cupressinites curtus* Bowerbank, p. 56, pl. x, figs. 20, 21.
1840. *Cupressinites thujoides* Bowerbank, p. 58, pl. x, figs. 22, 23.
1840. *? Cupressinites Comptonii* Bowerbank, p. 57, pl. x, fig. 34.
1845. *Cupressites curtus* (Bowerbank) Unger, p. 192.
1845. *Cupressites thujoides* (Bowerbank) Unger, p. 192.
1845. *? Cupressites Comptoni* (Bowerbank) Unger, p. 192.
1847. *Callitrites curtus* (Bowerbank) Endlicher, p. 10.
1847. *Callitrites thuioides* (Bowerbank) Endlicher, p. 10.
1847. *? Callitrites Comptoni* (Bowerbank) Endlicher, p. 10.
1849. *Callitrites curtus* (Bowerbank): Brongniart, p. 115.
1849. *Callitrites thuioides* (Bowerbank): Brongniart, p. 116.
1849. *? Callitrites Comptoni* (Bowerbank): Brongniart, p. 115.
1850. *Callitrites curtus* (Bowerbank): Unger, p. 345.

1850. *Callitrites thujoides* (Bowerbank): Unger, p. 346.
1850. *? Callitrites Comptoni* (Bowerbank): Unger, p. 345.
1879. *Callitris curta* (Bowerbank) Ettingshausen, p. 392.
1879. *? Callitris comptoni* (Bowerbank) Ettingshausen, p. 392.
1883. *Callitris curta* (Bowerbank): Gardner, p. 21, pl. ix, figs. 9–11.
1919. *Callitrites curta* (Bowerbank): Seward (pars), p. 340.

Diagnosis.—Fruit shortly stipitate, with four unequal finely-crumpled ovate-pointed valves; valves with thin margins and an external median concavity, without any umbo. Length of valves, 14·5 to 19 mm.; breadth, 9·5 to 14 mm.

Description.—*Fruit:* Shortly stipitate, four-valved; valves slightly unequal, ovate but always more or less pointed at the apex (except in the specimen *C. Comptonii*, if this be really the same species, with one pair of valves truncated), with a median concavity externally, thin at the margins when perfect, without any umbo, finely crumpled on the external surface; internal surface not seen.

Length of valves in largest specimen (slightly imperfect), 19 mm.; breadth, 14 mm. Length of the four valves in the smaller specimen respectively, 18, 16, 14·5 mm., and one imperfect; breadth of valves, 9·5, 10·5, 10·5, and 10 mm. respectively.

Discussion.—We have seen only two fruits which could be referred to *C. curtus*. One is larger than the other, more gaping, and with three of the four valves imperfect; the second is nearly perfect. Both are much encrusted with pyrites on the outside as well as on the inside of the valves. The arrangement and surface characters of these fossils leave little doubt that Bowerbank was right in referring them to the family Cupressineae. But after a study of that family in Kew Herbarium we are of opinion that the fruits are more nearly related to *Tetraclinis* Masters and *Widdringtonia* Endlicher than, as Bowerbank thought, to *Thuja orientalis* Linnaeus, for the reasons given below. A model was made of the smaller fossil cone, which showed that when its four scales were closed they must have met together at their apices, to produce a squat globose cone such as usually occurs in *Tetraclinis* and *Widdringtonia*. Their form leaves no room for an inner scale or whorl of scales such as is characteristic of *Thuja orientalis*. In that species there are four outer scales, truncated at their apices so as to abut against the inner whorl of scales which projects beyond them to form the apex of the somewhat elongate cone. In *Tetraclinis* the cones are variable in size, formed of four scales, and are usually without a columella (or inner whorl of scales), although very rarely it is present; one pair of opposite scales is slightly broader than the other pair; the broader scales tend to be pointed at the apex, the narrower scales tend to be more truncate and are concave on the exterior. The surface of both pairs of scales is smooth, the umbo is small, and the size of the cone is variable. In *Widdringtonia* the cones are much larger and more elongate, the difference between the pointed and truncate pairs of scales is more pronounced, the external surface is rougher, and the umbo is more conspicuous. A comparison with the description will show that the fossil bears a closer resemblance to *Tetraclinis* than to *Widdringtonia*. But in the absence of seeds, and of better preserved and more numerous cones, it seems desirable to retain the generic name *Cupressinites*, rather than to assume a generic relationship which cannot be proved conclusively. *Tetraclinis* grows in arid places in the Barbary States; *Widdringtonia* is native to tropical Africa, where it ascends to 6,000 feet in Rhodesia, 7,000 feet in the Chimanimani mountains. It also grows in South Africa, Madagascar, and Mauritius.

It has already been stated (p. 96) that of the species referred by Bowerbank to his genus *Cupressinites*, only three really belong to the Cupressineae—*C. curtus*, *C. Comptonii*, and *C. thujoides*. Of these, two—*C. curtus* and *C. thujoides*—should undoubtedly be referred to a single species, for which we have retained the name *C. curtus*, as this, unlike the name *C. thujoides*, does not suggest an erroneous living relationship. The types of these two species are no longer in existence. The specimen named *C. Comptonii* may also belong to *C. curtus*, but since it has one pair of scales definitely truncated and the other pointed, it is possible that it is specifically distinct. Unfortunately the specimen is no longer extant, so that its affinities cannot be settled beyond dispute by microscopic study. We have therefore referred *C. Comptonii* tentatively only to the species *C. curtus*.

For certain of the specimens figured by Gardner and by Seward as *Callitris* (or *Callitrites*) *curta*, see *Juglandicarya crassa* (p. 145), *Dunstania Ettingshauseni* (p. 459), and *Palaeorhodomyrtus subangulata* (p. 436).

V. 22004 Figured Pl. I, figs. 3, 4. Cone with gaping scales, the tip of one scale being broken.
V. 22005 Larger cone, all but one of the four scales are more or less broken.
Both belong to the Bowerbank Coll., Sheppey.

Family PODOCARPACEAE

Genus PODOCARPUS (L'Héritier) Persoon

1807. Syn., II, p. 580.

Podocarpus (?) *argillae-londinensis* Gardner

1883. *Podocarpus argillae-londinensis* Gardner, p. 52, pl. ix, figs. 35, 36.

The following is Gardner's description of a specimen, sent by Mr. Shrubsole, now no longer extant: "Fruit compressed, globose, nearly as long (sixteen millimètres) as wide (fifteen millimètres), deeply and finely wrinkled; apex small, not central, slightly produced and recurved; basal scar a small pit, sub-central, and inclining to the same side as the apex. The external wrinkled coat of the fossil represents the desiccated integument, while the next layer, probably the bony shell of the seed, is somewhat rough and pitted, and the nut, visible inside, is smooth.

"This fruit very strikingly resembles that of *P. elata* of Queensland . . . the determination resting entirely, in fact, upon the exceedingly strong likeness which the two bear to each other."

Gardner's description and figures do not agree very well. In the figures the fruit is in no degree compressed. We have before (Reid & Chandler, 1926, p. 48) had occasion to refer to the inaccuracy of some of his figures. All that can be said in the present instance is that the fruit is a sub-globose berry. It is much more probable that Gardner's specimen is one of the many abraded fruits of Lauraceae which occur in the Sheppey deposit, the external wrinkled coat probably representing the contracted endocarp (cf. *Laurocarpum paradoxum*, in which a similar although somewhat coarser system of wrinkles is produced by shrinkage, p. 227), the rough and pitted layer representing the testa, with the contents of its large secreting cells surrounded by pyrites which now represents the cell walls, and the smooth nut inside representing the internal cast of the seed. But in the absence of the specimen and of a more detailed description than Gardner gives the determination here suggested must be regarded as doubtful.

Under the generic name *Podocarpites* Andrae, Professor Seward (1919, p. 408) says: "Gardner also describes a globose wrinkled seed, 16 mm. in diameter, as ? *Podocarpus argillae-londinensis* . . . which bears a close resemblance to the seeds of *Podocarpus elata*."

Family TAXACEAE

Genus CEPHALOTAXUS Siebold & Zuccarini

1842. ex Endlicher, Gen. Suppl., II, p. 27.

Cephalotaxus Bowerbanki n. sp.

Plate I, figs. 5, 6.

Diagnosis.—Seed sub-globose or ovoid, with a ridge bisecting the pointed apex. Distinguished from other species by none (or few ?) of the fusiform cells in the outer integument being aligned transversely.

Holotype.—V. 22006.

Description.—*Seed:* Ovoid or sub-globular, divided into symmetrical halves at the pointed apex by a sharp straight ridge which dies out towards the rounded base (Pl. I, fig. 6). Testa bony (shown both by its thickness and by the way in which the seed has preserved its shape), formed of two coats. The thick and hard outer coat is itself made up of two definite layers with distinctive cell-structure. (*a*) At the surface there is a layer of large close-set, straight-sided hexagonal or polygonal cells which give a conspicuously tessellated appearance externally. These cells, which are about 0·1 mm. in diameter and 0·3 or 0·4 mm. long as seen in radial sections of the testa, are arranged so as to present a columnar appearance when seen in such sections. (*b*) Within this is a second layer several cells thick, formed in the main of large fusiform cells, angular in section, aligned more or less longitudinally but in rather a tangled manner, and with coarse angular parenchymatous cells interspersed among them. The inner surface of this outer coat of the testa (seen in one small patch only) shows the impression of a flat layer of large elongate cells aligned in various directions. The inner coat of the testa is much thinner than the outer; it has a rough surface and is formed of several layers of loosely compacted cells which are large and fusiform, aligned in various directions, and frequently grouped into conspicuous stellate clusters. Further, there are impressions of much smaller cells which indicate the probability of a third coat. Length of seed, 13 mm.; breadth, 12 mm.; thickness (imperfect), 10 mm. (?). Length of second seed, 15 mm.; breadth, 11 mm.; thickness (imperfect), 10 or 11 mm. (?). Thickness of outer coat of testa, 0·75 mm.

REMARKS.—Two specimens from Sheppey. The larger oval specimen is the internal cast of the hard outer integument covered by its worn-down remains. It shows clearly the tangled longitudinal alignment of the fusiform cells. The more globose specimen shows in part the complete thickness of the outer coat of the testa, its tessellated surface, the columnar arrangement of the external cells as seen in section, and the inner layers of coarse parenchyma and fusiform cells. On a small patch from which this outer coat has chipped away, the tangled cells which form its lining can be seen impressed on a film of pyrites. Where this pyrites layer is also chipped away the stellate groups of cells of the inner coat of the testa are shown very clearly in a few patches, and the impressions of the small cells can also be seen.

AFFINITIES.—We first looked for this species among large one-celled, one-seeded fruits, but there was none either among dicotyledons or monocotyledons to which it could be referred, for none shows its combination of characters. We therefore turned to the gymnosperms, to see whether, instead of being an endocarp, as we thought at first, it could be a gymnospermous seed. It at once became evident that it was comparable with the seeds of *Ginkgo* and *Cephalotaxus*. But although the fossil seeds somewhat resemble those of *Ginkgo* in size and shape, they differ from them essentially in the arrangement of the lateral angles or ridges at the apex, for in *Ginkgo* these two ridges meet at an angle instead of being continued over the apex in a straight line, so that they divide the nut into unequal halves. They also differ in the character of the integuments; the hard outer testa of *Ginkgo* is formed externally of elongate longitudinally aligned cells, with no radially directed columnar cells. The inner layers of the testa are formed of long cells aligned transversely. There is a diaphanous inner integument, but between it and the coats described above there is no layer of loosely compacted cells arranged in stellate groups as in the fossil.

The fossil seeds are, on the other hand, in the closest agreement with those of *Cephalotaxus*, more especially with such forms as *C. pedunculata* Sieb. & Zucc. var. *sphaeralis* Masters (length of seed, 14 mm.; breadth, 11 mm.), *C. drupacea* Sieb. & Zucc. var. *Harringtonia* Miq. form *sphaeralis* Vilgar (length, 15 mm.; breadth, 11 mm.), *C. drupacea* var. *sinensis* form *globosa* Rehd. & Wils., in all of which the seeds are relatively short and broad. In all species the lateral ridges are carried in a straight line across the apex and die out towards the base. In the only two species which we were able to examine microscopically, *C. drupacea* Sieb. & Zucc. and *C. Fortunei* Hook., the cells of the outer coat of the testa nearest the surface (corresponding to the layer *a* of the fossil) have a columnar arrangement in sections of the seed, but more of the fusiform cells of the inner layers of this coat (layer *b* of the fossil) are aligned in a transverse than in a longitudinal direction, although some are longitudinally aligned. In the fossil these cells do not appear to be aligned transversely, but it must be remembered that a transverse section can be seen only in one small patch, also that other living species and varieties which we were not able to examine microscopically may possibly have longitudinally aligned fusiform cells. The inner integuments of *Cephalotaxus* are two in number; the outer of these is formed of very large cells loosely compacted and arranged in stellate groups, such as have already been described as forming part of the inner coat of the fossil. The inner integument is diaphanous and formed of small longitudinally aligned cells; it would appear therefore to correspond to the innermost coat of the fossil, seen only in impression.

Cephalotaxus is now represented by about six species all very closely related. They are natives of the mountains of China and Japan. The habitat of the living species combined with the rarity of this genus among the London Clay plants, suggests that it may have been washed into the Eocene river by chance from some distant source, possibly from forest-clad mountains.

V. 22006 Holotype, figured Pl. I, fig. 5. Seed, somewhat broken, showing the successive layers of the testa.

V. 22007 Figured Pl. I, fig. 6. A second seed, also broken, but undistorted. It is a cast of the hard outer integument covered by its worn-down remains.

Both are from the Bowerbank Coll., Sheppey.

Family TAXACEAE (?)

Genus (?)

Plate I, figs. 7, 8.

Description.—*Seed:* Large, roundly triangular in section, the angles being clearly marked at the apex (Pl. I, fig. 8) but becoming more and more rounded towards the base where they disappear (cf. Pl. I, fig. 7); each face slightly obovate, the apical end being rather rounded and the base rather pointed; at the apex is a small central hole (the micropyle ?). Testa thin (as preserved), formed of two coats, the outer consisting of layers of fibres which have an irregular transverse alignment, and the inner of layers of fibres with an irregular longitudinal alignment. Occasionally where both these layers have been worn away the impressions of rounded cells (0·0125 mm. in diameter) are seen. These are slightly inflated and are for the most part rather roundly square or oblong and transversely aligned, but some are irregularly angular. Length of seed, 20 mm.; breadth of faces, 11·5 mm., 9·5 mm., and 9·5 mm. respectively.

Remarks.—One specimen, which was fractured transversely before it came into our hands. It is the internal cast of a seed to which parts of the testa still adhere. On its surface in one or two small areas are the impressions of the cells of the inner coat described above.

Affinities.—This seed must not be confused with *Carpolithus* sp. 39 (see p. 529). Although of identical size, it differs from that species essentially in its much more rounded angles and especially in the structure of its coats. Instead of the single coat of fine parenchyma which forms the testa in *Carpolithus* sp. 39, there are two fibrous layers as described above; and instead of an inner thin layer of smooth, flat, thin-walled glistening cells, there is the layer of rounded or polygonal inflated cells. The size and shape of the seed suggest at once comparison with the seeds of various members of the family Coniferae, and it is possible that this is its relationship. The seeds of *Taxus* (Tourn.) Linn. (Taxaceae) and *Podocarpus* (L'Hérit.) Pers. (Podocarpaceae) are both conspicuously triangular at the apex, which, as in the fossil, is pierced by the micropyle; at the base they, and the seeds of other members of the family Taxaceae, are rounded. In this respect, therefore, the fossil recalls this sub-family, and it is of similar size to the nuts of *Cephalotaxus* Sieb. & Zucc. and *Torreya* Arn., although those of the latter genus and of *Ginkgo* Linn. are relatively shorter and stouter. But the substance of the coats is too decayed, and the specimen is too imperfect to permit of any really satisfactory comparison.

V. 22008 Figured Pl. I, figs. 7, 8. A nut fractured in two, and broken on one side. Labelled "*Tricarpellites crassus* Bow." by Ettingshausen. It is certainly not Bowerbank's genus or species. *Bowerbank Coll.*, Sheppey.

Genus CUPRESSINOXYLON Goeppert

1850. Monographie der fossilen Coniferen, p. 196.

Cupressinoxylon Holdenae Seward

1919. *Cupressinoxylon Holdenae* Seward, p. 194, fig. 718*c*.

Wood, from the London Clay of Faversham, characterized by well-defined annual rings and the presence, in some but not all the bands of summer wood, of resin canals. For a full description reference should be made to Professor A. C. Seward's account. The original specimen is in the Cambridge Botany School.

Monocotyledones

Family PALMAE

Except in the case of *Sabal*, of which fragmentary leaves are preserved, the Palmae are only represented in the London Clay by seeds. Hence it was necessary to study as fully and carefully as possible all available fruits and seeds of the family. We were able to make macroscopic studies of the seeds of the majority of genera, but not, by any means, of all the species. By close and careful observation of the form and size of the seed itself; the form and position of hilum, raphe, and chalaza; the position of the embryo; the presence or absence of ruminations, and their character when present; the nature and structure of the testa; and especially by the combinations of these characters, it was possible with a considerable degree of certainty to discriminate between the seeds of most genera. Consequently, when comparison between fossil and recent species was attempted, it was in some cases, although not always, possible to eliminate from comparison all but a few genera, or in some cases all but one genus.

We have distinguished thirteen different species of palms (exclusive of *Nipa*, which has been referred to the distinct family Nipaceae, p. 118). Five of these—possibly six—are related definitely to living genera, but it is doubtful whether in every case the relationship is sufficiently close to admit of inclusion within the living genus or whether some may not represent closely allied extinct genera. The remaining seven species which, for want of sufficient characterization in the fossil, or for want of comparable living material, we have not been able to place with certainty, are described under the form genus *Palmospermum*.

It might be thought from the list of species that, as was formerly believed, palms were very common in the London Clay, but this does not necessarily follow, because no species is represented by more than a very few specimens, and some are represented by one seed only.

The genera recorded by us are entirely different, except in the case of *Sabal*, from those listed by Ettingshausen. Many of his so-called palms have proved to belong to quite other families.

Section *ONCOSPERMEAE*

Genus ONCOSPERMA Blume

1836. Rumphia, II, p. 96.

Oncosperma (?) *anglica* n. sp.

PLATE I, figs. 9, 10.

DIAGNOSIS.—Seed sub-globular with shallow ruminations; raphe scar ligulate, extending the whole length of the ventral face, ending in the oboval chalazal scar; embryo close to the hilum, in the plane of symmetry. Testa smooth, formed of fusiform cells; ruminations netted, surface slightly corrugate around the ventral scar. Seed larger than those of *O. filamentosa*, which are globular.

HOLOTYPE.—V. 22009.

DESCRIPTION.—*Seed:* Sub-globular with a broad, deep conspicuous furrow (the raphe furrow), which extends the full length of the ventral face and terminates at one end in the oboval chalazal scar, at the other in the hilum (Pl. I, fig. 9). In close contiguity with the hilum in the plane of symmetry is the circular scar of the embryo (Pl. I, fig. 10). The external surface of the testa (preserved in a few scattered fragments) is smooth, and is formed of fusiform cells beneath which the outer polygonal ends of the albumen cells can be seen as impressions over the greater part of the surface. In a few places the linear impressions of a network of ruminations can be traced, and a series of slight corrugations (Pl. I, fig. 9) radiating from the raphe and chalaza may also be associated with ruminations. Length of seed, 12 mm.; breadth, 11 mm.

REMARKS.—A single seed, preserved as the internal cast, to which a few fragments of the testa still cling. The cast is perfect save for a few patches where its surface has decayed.

Affinities.—The study of our drawings of palm seeds, checked by reference to living material in Kew Herbarium, led to the conclusion that the seeds of *Oncosperma* most resemble the fossil. In these the raphe is both expanded and much thickened, and is fused with the wall of the endocarp. On removal of the seed from the fruit, the raphe still adheres to the endocarp and forms a large spathulate scar on its ventral wall. Its detachment from the seed exposes a deep groove like that of the fossil, terminating at one end in an oboval chalazal scar, and at the other in the circular scar of the embryo. The cells of the testa and of the endosperm are identical with those of the fossil, but the network of ruminations in *O. filamentosa* Bl. (with which species we were able to make the closest comparison) is considerably coarser than the network which apparently corresponds to it in the fossil. Also the fossil seed is larger than the seeds of *O. filamentosa* and is longer than broad, whereas those of the living species are globular.

On account of these differences we have referred the fossil doubtfully to the genus *Oncosperma,* although fossil and living must undoubtedly be closely related.

Oncosperma belongs to the section Oncospermeae of the tribe Areceae (Hooker). The genus consists of small palms inhabiting the Indo-Malayan region.

V. 22009 Holotype, figured Pl. I, figs. 9, 10. Seed as described above. *W. Griffiths Coll.*, Sheppey, 1858.

Section *CARYOTIDEAE*

Genus CARYOTISPERMUM nov.

Diagnosis.—Seed globular, ruminate, with corrugations diverging from the ventral scar and embryo, formed of three fused seeds (?), but only one embryo developed. Embryo lateral midway between the base and apex. Differing from *Caryota* in apparently having three fused seeds instead of two, and in the embryo being nearer the ventral scar.

Genotype.—*C. cantiense.*

Caryotispermum cantiense n. sp.

Plate I, figs. 11, 12.

Diagnosis.—That of the genus.

Holotype.—V. 22010.

Description.—*Seed:* Globular, highly ruminate and corrugate, the corrugations diverging from the base and from the embryo. Formed of three fused seeds (?) as possibly indicated by the three grooves which diverge from the corners of a three-angled attachment area. One embryo only developed, lateral, lying about half-way between the base and the apex (Pl. I, fig. 11). Length of seed (somewhat crushed and distorted at the apex), 9 mm. ; breadth, 10 mm.

Remarks.—One seed represented by the internal cast of the testa with the remains of an integument still adhering around the hilum as a small, prominent, triangular patch. At the centre of this patch, which is formed of polygonal cells, there is a passage for nutrient fibres (Pl. I, fig. 12). It is not possible to ascertain whether the integument thus preserved represents the testa only, or the pericarp fused with the testa. The embryo cavity is beautifully preserved. Also in one of the grooves on the surface of the seed impressions of large polygonal cells can be seen, but whether these belonged to the testa or to the albumen is by no means certain.

AFFINITIES.—The most important diagnostic characters of this fossil are the size and form, the high degree of rumination of the albumen, the apparent fusion of more than one seed, and the position of the embryo. In attempting to discover its affinities, we first listed all palms with ruminate seeds. From these we eliminated by reference to descriptions, to our own drawings, and to living seeds, all which had not excentric embryos. We finally reached the conclusion that comparable form and size, similar ruminations radiating from hilum and embryo, and similar indications of the fusion of more than one seed are to be found in the genus *Caryota* Linn. only. In size the fossil most resembles *C. mitis* Lour. ; in its ruminations it is more like *C. urens* Linn. But in spite of many similarities, there are essential distinctions between it and *Caryota*. Thus the living genus may have one or two seeds, fused or unfused, but not three ; also the embryo is always nearer the apex of the seed, *i.e.* more dorsal, than in the fossil. We asked Mr. H. N. Ridley his opinion of its relationship, and after expressing astonishment at the beautiful manner of preservation, he said, without hesitation, "Caryotideae," adding, "very close to *Caryota*." Whilst, therefore, we regard *Caryota* as the nearest living ally, the position of the embryo in the fossil and the apparent fusion of three seeds preclude it from inclusion within the genus. We have named it *Caryotispermum cantiense*, to indicate that it is related to, but distinct from *Caryota*.

Caryota is a genus of essentially tropical palms inhabiting India, Ceylon, the Malay Peninsula and Archipelago, and the north coast of Australia.

V. 22010 Holotype, figured Pl. I, figs 11, 12. Seed as described above. *Bowerbank Coll.*, Sheppey.

Section *CORYPHEAE*

Genus SABAL Adanson

1763. Fam. Pl., II, p. 495.

Sabal grandisperma n. sp.

PLATE I, figs. 13–15.

1879. *Diospyros eocenica* Ettingshausen (pars), p. 394.

DIAGNOSIS.—Seed lenticular, 10 mm. in diameter, ventral face flattened but with a large circular depression filled by the raphe, and associated thick plug. Embryo-scar excentric in the dorsal surface. Testa thin, corrugated, and wrinkled.

HOLOTYPE.—V. 22011.

DESCRIPTION.—*Seed:* Lenticular, probably more or less hemispherical when uncompressed, dorsal surface convex, ventral surface more or less flattened, bearing a large hilar and chalazal plug of loose textured tissue pierced at its centre by a foramen for the passage of the vascular strands (Pl. I, fig. 13). Beneath the plug and completely filled by it, as shown in abraded specimens, or by fracture, there is a conspicuous, sub-circular, ventral hollow. At one point it is prolonged into a narrow furrow, which is continued almost on to the dorsal surface in the neighbourhood of the embryo. This furrow is filled by a tongue-like prolongation of the plug. Dorsal surface with a small but conspicuous excentric circular tumid scar (Pl. I, fig. 14), which marks the position of the embryo. Testa (more or less removed by abrasion) probably thin except where associated with the hilar plug. Surface of cast corrugated and wrinkled (certainly an original character although possibly accentuated by shrinkage and compression); around the ventral plug the wrinkles diverge from its margin. External surface of testa not seen, internal surface formed of fine polygonal cells giving a granular appearance to the cast; there are also traces of a striate coat, but the relation of these two coats has not been ascertained. Diameter of seed, 10 mm.; thickness from base to convex surface (somewhat compressed), 5 mm.

REMARKS.—Two specimens found, together with fruits and seeds representing other families or genera, in a jar labelled by Ettingshausen "*Diospyros eocenica* Ett." Both specimens were compressed dorsi-ventrally, and one was imperfect on one side. The perfect specimen was fractured in order to ascertain its structure. Both are internal casts of the seed-cavity. In one the hilar-chalazal plug adheres over the ventral depression, in the other it is completely abraded.

AFFINITIES.—The specimens show no relationship to *Diospyros;* but their form, with the deep ventral depression filled by loose tissue, and the presence of the embryo-scar indicate that they are palm seeds. They resemble those of *Sabal*, which are readily distinguishable by their appearance from the seeds belonging to other genera of palms. Among the seeds of *Sabal* those of *S. palmetto* Lodd ex. Schult. are smaller, also those of *S. Adansonii*, whilst those of *S. Blackburniana* may be of the same size. In this connexion we note that a large living seed in a collection made by Ettingshausen was labelled *S. Adansonii;* it closely resembles the fossil but probably belongs to *S. Blackburniana*. Many species of *Sabal* have seeds with crumples and corrugations such as are seen in the two fossil specimens.

We note in the following section the occurrence of a leaf of *Sabal*. Although leaves have often been recorded fossil from Tertiary strata, we have not seen a previous record of the seed.

Sabal inhabits the tropics and sub-tropics of North, South, and Central America. It extends into the Antilles.

V. 22011 Holotype, figured Pl. I, figs. 13–15. A seed somewhat compressed from apex to base, now in four fragments. It shows the embryo-scar and the hilar-chalazal plug. Testa abraded, except where the plug is preserved.

V. 22012 A second seed, imperfect on one side. Much crushed. The testa is completely removed by abrasion even over the hilar-chalazal region, where the ventral hollow is therefore exposed. The cast shows the embryo-scar.

Both specimens were in a jar, with Lauraceae and other plant remains, labelled by Ettingshausen, *Diospyros eocenica* Ett. *Bowerbank Coll.*, Sheppey.

Sabal sp. (*grandisperma?*)

PLATE I, figs. 16, 17.

1879. *Sabal major* (Unger): Ettingshausen, p. 393.

DESCRIPTION.—*Leaf:* Fan-shaped, represented by fragments only. Rachis long and stout, convex and tapering on lower surface (length incomplete); narrow and relatively inconspicuous on the upper surface. Ligule large, broadly triangular, adherent except at the margins. Petiole not preserved. Pinnae small and close especially towards the base of the leaf where they are reflexed, broader and straighter above. Numerous fibro-vascular bundles can be seen throughout the substance of the leaf embedded in tissue formed of transversely elongate cells. In the rachis the vascular bundles are formed of spirally thickened fibres. Length of largest leaf fragment, 40 mm.

REMARKS.—Three good fragments belong to the same species; also several small fragments, with but a few pinnae, may belong to the species, whilst others probably do not. The three larger fragments show the remains of the rachis with the bases of pinnae. They are of unusual value in that they are separate entities free from matrix, in which it has been possible to study both the upper and lower surfaces of each specimen. They retain the original cell-structures, but are impregnated throughout with pyrites which fills every cell.

AFFINITIES.—The three larger leaf fragments must be referred to a species of *Sabal*, as shown by the form of the adherent ligule, and the character of the rachis which is long, broad, and prominent on the lower surface, but narrow and flat on the upper surface. It is possible that they belong to *Sabal major* (Unger) so frequently described from Tertiary strata. But in our opinion the evidence is insufficient to permit of definite reference to a species which is only known from younger beds. Possibly they may belong to the same species as the seeds described as *Sabal grandisperma* (p. 105), but it is doubtful whether all the leaf fragments belong to one species, that is, whether more than one species may not be represented in the London Clay. Moreover, it often happens that several species of a genus occur fossil in one deposit; hence the leaves and seeds of *Sabal* in the London Clay cannot be proved to belong to a single species.

V. 22013 Figured Pl. I, figs. 16, 17. A portion of a leaf, showing the rachis and a few pinnae. On the upper surface the ligule is well preserved, and the thin upper side of the rachis is visible. On the lower surface the stouter lower side of the rachis can be seen. On one side of the axis a few pinnae-bases are alone preserved. These were broken away when we received the specimens, but were placed in their correct position for the purpose of photographing the leaf. On the opposite side of the axis a larger number of pinnae are preserved, and a few more were subsequently found, after the specimen had been photographed, which had been detached from the base. The specimen was labelled "*Sphaeria Flabellariae*" by Ettingshausen. The supposed fungi were small blobs of pyrites.

V. 22014 A fragment showing pinnae and part of the rachis. The ligule is much abraded. Labelled by Ettingshausen, "*Sabal major* Ung."

V. 22015 A broken fragment of a large leaf with pinnae on both sides of the rachis. Labelled "*Sabal major* Ung." by Ettingshausen.

V. 22016 Several small fragments of palm leaves each composed of a few pinnae. Some may be species of *Sabal*. All are too poor for determination. Labelled "*Sabal major*" by Ettingshausen.

The above are all Bowerbank Coll., Sheppey.

Genus SERENOA Hooker fil.

1883. In Bentham and Hooker f., Gen. Pl., III, p. 926.

Serenoa eocenica n. sp.

PLATE I, figs. 18, 19.

1879. *Diospyros eocenica* Ettingshausen (pars.), p. 394.

DIAGNOSIS.—Seed obovoid; raphe and chalaza-scar large, spathulate, and thick, covering a deep depression. Embryo-scar small and circular, near the hilum, in the plane of symmetry, on the dorsal surface. Testa thin, corrugated around the chalaza, finely striate internally. Half as large again as the round seeds of *S. arborescens*, and two-thirds the size of the obovoid seeds of *S. serrulata*.

HOLOTYPE.—V. 22017.

DESCRIPTION.—*Seed:* Obovoid, bisymmetric, hilum terminal at one end, raphe ventral, thick, broadening gradually into the large spathulate external scar of the chalaza, which fills a deep ventral hollow (Pl. I, fig. 18). Embryo-scar small, circular, in the plane of symmetry on the dorsal surface near the hilum (Pl. I, fig. 19). Testa thin, black (as preserved), with wrinkles or corrugations radiating from the margin of the chalaza but not passing on to the dorsal surface; internal surface of testa having fine striations, formed of elongate cells, which also radiate from the margin of the chalaza. Beneath the striate layer small polygonal cells can be seen as impressions upon the surface of the pyrites-cast. The large, polygonal cells of the thick external chalaza-scar are of varying size. Greatest diameter of seed, 7·5 mm.; transverse diameters, each 6 mm.

REMARKS.—A fine specimen, collected at Minster (V. 22017), is the internal cast of a perfect but somewhat crushed seed to which fragments of testa and the whole of the thick raphe and external chalaza still cling. There are two additional specimens in a more abraded condition with the raphe and external chalaza worn away completely so as to expose the underlying concavity on the ventral surface of the seed.

AFFINITIES.—At first sight this fossil shows a superficial resemblance in its shape and in that of its large ventral chalaza to an endocarp of *Meliosma* with its plug, or to a seed of a large vine with its conspicuous chalaza. But a careful examination shows that it belongs to neither of these genera. The round embryo-scar places the seed beyond a doubt in the Palmae; there is no corresponding scar in the Sabiaceae or Vitaceae. The non-ruminate seed with thick spathulate chalaza-scar occupying the greater part of the ventral surface is characteristic of the section Corypheae of the Palmae. The genera which show the closest relationship are *Serenoa* Hook. f., *Corypha* Linn., *Licuala* Thunb., and *Livistona* R. Br. The seeds of *Serenoa serrulata* Hook. f. approach most closely to the fossil seeds. The other genera enumerated have in certain species seeds which resemble the fossils in size and shape, but in all the embryo is more distant from the hilum. Only in *Serenoa* does the embryo occupy the same relative position as in the fossil. The seeds of *S. arborescens* Sargent (doubtfully referred by him to the genus *Serenoa*) are round, about two-thirds the size of the fossil, but with the embryo similarly placed. The seeds of *S. serrulata* agree in every way with the fossil except that they are half as large again. But such differences of size cannot be regarded as of generic value. We have therefore referred the fossils to *Serenoa*, under the name *S. eocenica*.

Serenoa is represented by but two living species—*S. serrulata*, a native of the Pine Barrens, United States, and *S. arborescens*, a native of the Everglades of Florida and South Carolina.

V. 22017 Holotype, figured Pl. I, figs. 18, 19. A well-preserved though slightly crushed seed with remains of testa. Hilar-chalazal scar preserved. *Reid & Chandler Coll.*, Minster, 1929.

V. 22018 Much abraded seed. Testa and chalazal scar completely worn away. *Reid & Chandler Coll.*, Minster, 1929.

V. 22019 Much abraded seed. Testa completely gone, chalazal scar also abraded. The specimen was in a jar among Lauraceae and other plants labelled " *Diospyros eocenica* " by Ettingshausen. *Bowerbank Coll.*, Sheppey.

Serenoa sp. (?)

Plate I, fig. 20.

Description.—An internal cast of a seed (?), much resembles *Serenoa serrulata* in size and shape, and further shows a long, narrow depression on one side, similar to the ventral depression associated with raphe and chalaza in that species. But the fossil seed is asymmetric. The depressed area being curved to one side at the narrow end, there is no indication of any embryo-scar, and, in addition, such minute fragments of testa as are preserved are not very clearly indicative of palms. The absence of an embryo-scar is not in itself decisively against ascription to Palmae, for in internal casts of seeds, such as the fossil, the impression of the embryo-scar is not always preserved.

V. 22020 Figured Pl. I, fig. 20. The internal cast of a seed as described above. *Reid & Chandler Coll.*, Minster, 1929.

Genus LIVISTONA R. Br.

1810. Prod., p. 267.

Livistona (?) minima n. sp.

Plate I, figs. 21, 22.

Diagnosis.—Seed non-ruminate, sub-globular, with deep circular ventral chalazal depression and broad raphe channel. Embryo in the plane of symmetry near the middle of the dorsal face. Seed smaller than any species of *Livistona* we have seen, 9 mm. long without testa.

Holotype.—V. 22021.

Description.—*Seed:* Non-ruminate, sub-globular, somewhat compressed dorsiventrally, deeply hollowed on the ventral face (as preserved), the hollow being circular in outline and having steep walls except at one end where there is a shallow broad channel (Pl. I, fig. 22) ; the hollow and channel mark the plane of bisymmetry of the seed; they also mark the position of the hilum, raphe, and chalaza, the external chalaza and raphe having filled the hollow and channel, before they were removed by decay and abrasion. The narrow end of the hollow corresponds to the hilum and raphe, the broad end to the chalaza. The embryo lies near the middle of the rounded dorsal side in the plane of symmetry (Pl. I, fig. 21). The testa is almost completely abraded, but in a few places, in hollows on the surface of the cast, are impressions of the polygonal ends of the albumen cells. The surface of the cast is faintly wrinkled on the ventral side, the wrinkles radiating from the hollow. Length of seed (without testa, measured along the plane of symmetry), 9 mm.; diameter (at right angles to length, also measured in the plane of symmetry), 7·5 mm.

REMARKS.—One seed represented by an internal cast to which a few patches of testa still adhere. As stated above, the organic substance of the thick raphe and chalaza has completely vanished leaving a hollow on the ventral surface. A semicircular patch of pyrites, partly merging on one side into the general surface of the cast, marks the position of the embryo. This pyrites was chipped away and the smooth incurved edges of the small cylindrical cavity for the embryo were then exposed.

AFFINITIES.—The non-ruminate palm seeds which most resemble this fossil in form, which show a similar position of the embryo, and which, if the testa and raphe were removed, would show a similar deep ventral hollow, are those of *Livistona* (section Corypheae). In no other genus, so far as we have been able to observe, is the combination of these three characters to be found. We therefore feel satisfied that the seed is closely related to *Livistona*, but it is smaller than any specimens we have seen, the smallest seeds, those of *L. australis* Mart., measuring 12·5 × 10 mm. Moreover, we have not seen the testa of the fossil. We have therefore referred it tentatively to the living genus.

Livistona is a palm inhabiting eastern Asia from south China to the Malayan Islands and extending its range into tropical and sub-tropical regions along the east coast of Australia.

V. 22021 Holotype, figured Pl. I, figs. 21, 22. A seed-cast from which the testa has been abraded so as to expose on one side the embryo-scar, and on the other the deep excavation associated with hilum and chalaza. *Bowerbank Coll.*, Sheppey.

Genus PALMOSPERMUM nov.

DIAGNOSIS.—Seeds of variable shape, which by the character of their hilum, chalaza, or embryo can be referred to the family Palmae although their more exact affinities are not known.

Palmospermum Jenkinsi n. sp.

PLATE I, figs. 23, 24.

DIAGNOSIS.—Seed sub-globular, with a large deep sub-circular ventral scar and hollow which narrows into a broad shallow raphe channel. Embryo sub-basal close to the hilum in the plane of symmetry. Diameter, 7–9 mm.

HOLOTYPE.—V. 22022.

DESCRIPTION.—*Seed :* Sub-globular, but flattened on the ventral surface where there is a large deep chalazal scar, circular for the greater part of its circumference, but narrowing at one end into a broad shallow channel for the raphe (Pl. I, fig. 23). The centre of the chalaza is covered by a prominent mass of tissue apparently pierced by a small foramen. The embryo-scar is circular and convex, situated close to the hilar end of the depression which carries the raphe, so that it is nearly basal (Pl. I, fig. 24). Testa missing, but the surface of the cast shows the impressions of polygonal cells. Length of seed (as preserved), 8 mm. ; breadth, 9 mm. ; thickness, 7 mm.

AFFINITIES.—The character of the seed, with its large ventral chalaza and its small basal embryo-scar, leaves no doubt that it must be referred to the Palmae, but we have been unable, among the somewhat limited material available for study, to find any genus with seeds that exactly correspond with the fossil. Hence we have been obliged to refer the specimen to the form-genus *Palmospermum,* while to mark its distinctness we have given it the specific name *P. Jenkinsi* in honour of the finder.

V. 22022 Holotype, figured Pl. I, figs. 23, 24. A perfect internal cast of a seed from which the testa has been completely abraded except over the chalazal region. *D. J. Jenkins Coll.,* Herne Bay, 1929.

Palmospermum excavatum n. sp.

PLATE I, figs. 25–27.

DIAGNOSIS.—Seed non-ruminate, sub-globular with a deep ventral depression occupied by the raphe and chalaza, a large circular scar (internal chalaza) covered by a network of fibres abutting on this depression ; seed-coat (testa and endocarp fused ?) thick, inner coat a single layer of cells radiating from the ventral cavity, middle coat several thicknesses of fusiform cells similarly aligned, outer coat thick, cells indistinguishable. Embryo not seen. Length, about 9–15 mm.

HOLOTYPE.—V. 22023.

DESCRIPTION.—*Seed :* Non-ruminate, sub-globular, with a deep ventral concavity which is occupied by the greatly thickened chalaza and raphe. When the testa is removed (as the result of abrasion) the opening of the cavity is seen to be sub-spathulate, truncate at the chalazal end and with a narrow slit-like prolongation at the opposite end (Pl. I, fig. 25). On the internal cast of the seed a large circular scar (internal chalaza) abuts on the truncate end of the ventral cavity ; a network of fibres radiates from the raphe over the surface of this scar, and terminates abruptly at its edge (Pl. I, fig. 27). Seed-coat (testa and endocarp fused ?) thick ; the inner layer, lining the seed-cavity, one cell thick, formed of long thin-walled cells directed away from the margin of the deep ventral hollow ; the coat external to this, probably several cells thick, is formed of long fusiform cells smaller than those of the innermost layer, and like them everywhere directed away from the ventral cavity. The circular scar with its fibres lies immediately outside this coat. Exterior to this is a thick coat of close cells the form of which could not be distinguished ; it may represent, in part at least, the endocarp, the previously described coats representing the testa, all coats having been fused. The thickened raphe is formed of fibres and parenchyma. We have been unable to detect the embryo-scar, possibly because, as in some Palmae, it may have lain within the hollow associated with the raphe, or possibly because the mode of preservation has failed to show it clearly. Diameter of largest specimen, 15 mm.; diameter of smallest specimen, 9 mm.; thickness of integument (as preserved), about 1·5 mm.

REMARKS.—Six specimens, all similarly preserved, represent the internal casts of seeds to which considerable portions of the integuments may adhere on the dorsal surface. On the ventral surface they have usually been removed by abrasion. Since they have often decayed around or even within the ventral concavity, the raphe remains as a more or less isolated "plug" lying within the hollow. One of the larger seeds (Pl. I, fig. 27) was fractured, in order to discover the relation between the plug and the seed-cast. The plug was found to be quite separate from the ventral hollow and fell free from it, carrying with it the portion of the integument which lined the bottom of the hollow. It was formed of pyritized carbonaceous tissue. The smooth walls of the ventral cavity showed most clearly the impression of the lining layer of the testa. The cells forming the outer layers of the testa were also preserved behind the plug, which evidently afforded protection from decay and abrasion. In the hope of finding evidence of the embryo, the integument was chipped away from the dorsal surface of another seed (Pl. I, fig. 25), but no trace of it was discovered, although we were fortunate in discovering the internal chalazal scar (Pl. I, fig. 26).

AFFINITIES.—Although we have been unable to see the embryo-scar, there seems no reason to doubt that these seeds belong to a palm. Palm seeds of somewhat similar shape, deeply excavated on the ventral face, and with a greatly thickened raphe forming a plug that completely fills the excavation, are not uncommon. Also in many palm seeds the raphe branches to form a similar chalazal network over the internal surface of the testa, and in addition the cell structure may be similar in palms. The limited living material available for sectioning has not permitted us to make by any means an exhaustive study of the size, form, and depth of the ventral concavities of palm seeds. But so far as our study has gone, we have found in *Erythaea* S. Wats. seeds of somewhat similar size and shape with almost equally deep, large, concavities from which the raphe-plug comes smoothly away carrying with it a portion of the testa, and leaving the shining wrinkled surface of the albumen (=internal cast of the seed in the fossil) exposed, much as happened in the fossil which we fractured. Such a severance of testa from albumen appears to be most exceptional; usually the two are so closely fused that it is difficult to separate them even by maceration. In *Erythaea* the cells of the testa and of the testa-lining are also somewhat comparable with those of the fossil, except that the lining cells are smaller and less regular and the testa itself is crumpled. In the absence of any evidence as to the position of the embryo, we do not wish to imply any relation to *Erythaea*; we merely use the evidence that the genus affords of a probable relationship between the fossils and the Palmae. So far as our studies of seeds have led us, the only other possible explanation of these specimens is that they are endocarps related to *Meliosma*. But the position of the chalaza, the system of branching fibres which form it, and the character of the cell-structure, forbid such an ascription.

A seed of this species is illustrated by Crow, as number 642 in his manuscript catalogue (1810).

V. 22023 Holotype, figured Pl. I, figs. 25, 26. A seed-cast with much testa originally preserved over the apex and dorsal surface. The testa was subsequently removed and the specimen now shows the internal chalazal scar. Immediately around the hilum and raphe the testa was not preserved, hence the thickened raphe appeared as an isolated plug lying within the ventral hollow.

V. 22024 Figured Pl. I, fig. 27. A seed-cast with much testa preserved in the ventral hollow. After photography the seed was fractured to show the plug (formed by the pyritized raphe) and its relation to the cast of the seed-cavity.

V. 22025 A large seed with most of the testa abraded.
The above are all Bowerbank Coll., Sheppey.

V. 22026 An internal cast of a seed. *Reid & Chandler Coll.*, Minster, 1929.

V. 22027 An imperfect seed which may belong to *P. excavatum*. *D. J. Jenkins Coll.*, Herne Bay.

V. 22028 A small seed (in two pieces) which may belong to *P. excavatum*. The preservation is poor and the determination doubtful. *Bowerbank Coll.*, Sheppey.

Palmospermum parvum n. sp.

Plate I, figs. 28, 29.

Diagnosis.—Seed non-ruminate, sub-globular, with a deep elongate ventral depression ; embryo in the plane of symmetry, close to the hilum ; outer integument (? endocarp and testa fused) of coarse parenchyma ; inner integument thin, crumpled, formed of small cells aligned in longitudinal rows on the dorsal face, but radiating from the ventral hollow.

Holotype.—V. 22029.

Description.—*Seed :* Non-ruminate, sub-globular, with a deep elongate parallel-sided depression on the ventral face occupied by the thickened raphe. The inner chalaza appears as a well-defined circular scar (Pl. I, fig. 29) abutting on one end of the cavity, but the fibres which originally radiated over its surface have been almost obliterated by abrasion. The embryo lies at the hilar end of the ventral cavity, but a little removed from it. The integument (for the most part broken away) is formed of rather coarse parenchyma. It probably represents the endocarp, or the fused endocarp and testa. Within is a thin, shining, somewhat crumpled coat, formed of small cells which are aligned in more or less longitudinal rows over the dorsal surface ; on the ventral surface the cells radiate from the margin of the ventral depression, the actual centre of alignment (as preserved) being a little knob in the middle of a median ridge. The knob and ridge are associated with the hilum and raphe. Length of seed, 6·5 mm. ; breadth, 6 mm. ; thickness, 5 mm.

Remarks.—One specimen, the internal cast of a seed to which a portion of a thick integument still adheres in the neighbourhood of the embryo-scar. As this coat quite obscured the embryo and thereby prevented any possibility of discovering the relationship of the seed, part of it was chipped away, thus exposing the position of the embryo and the structure of the coat itself.

Affinities.—The seed is undoubtedly that of a palm. In the character of the deep ventral depression and the position of the embryo it recalls *Erythaea*, but the seeds of those species of *Erythaea* which we have seen are considerably larger and have a more irregular surface. We cannot therefore refer it to that genus, although it may be allied to it. It differs from *Palmospermum excavatum* (p. 111) in being less globular and much smaller, in the ventral depression being nearly parallel-sided and without the central expansion seen in *P. excavatum*, in the lining cells of the testa being oblong and definitely aligned in rows over its whole surface (not irregularly polygonal and irregularly aligned as in *P. excavatum*), and in the surface of the cast being finely crumpled, not smooth.

V. 22029 Holotype, figured Pl. I, figs. 28, 29. A seed which has lost most of the testa. *Bowerbank Coll.*, Sheppey.

Palmospermum minimum n. sp.

Plate I, figs. 30, 31.

Diagnosis.—Seed very small, ovoid, ruminate (?), with a deep oval ventral depression contracting towards the hilar end, and filled by parenchyma (the thick raphe and chalaza). Embryo in the plane of symmetry, close to the hilum, on the dorsal face. Testa (around the depression) showing fine striations radiating from the hollow. One specimen shows a network of black lines (? ruminations).

Holotype.—V. 22030.

Description.—*Seed:* Very small, ovoid, ruminate (?), with a large oval depression on the ventral face filled by the loose parenchymatous tissue of the thick raphe and chalaza. The depression contracts at the hilum end into a shallow channel (Pl. I, fig. 30). Immediately opposite the end of this channel, and closely adjacent to it, although situated upon the dorsal surface of the seed, is the circular scar of the embryo (Pl. I, fig. 31). Testa almost completely abraded, but remaining around the margin of the chalazal depression, where in a few places polygonal cells overlie the impressions of fine striations which radiate outwards from the margin of the depression. In one specimen the surface is in part faintly laced with an irregular network of thin black lines, which, occasionally, are very slightly depressed below the general surface. It is possible that these lines merely represent a peculiar preservation of the testa, but they may represent the surface impressions of ruminations. If the latter explanation be correct then the ruminations must have been very shallow. Length of seed, 6·6 mm.; breadth, 5 mm.; thickness (excluding the chalazal plug), 4·5 mm.

Remarks.—Two seeds represented by internal casts. In one seed the remains of the thick chalaza and raphe adhere to the surface of the ventral depression. Both seeds have lost the testa and the surface has been rubbed so smooth that even the impressions of the testa cells are gone, except around the margin of the chalazal depression. The embryo-scar is clearly marked in both specimens.

Affinities.—There can be no doubt that the seeds are those of a species of palm. In general shape they resemble those described as *Serenoa eocenica* (see p. 108) and the position of the embryo is the same, as also is the structure of the seed coats. We do not consider that these seeds can be referred to *S. eocenica* because the three seeds which represent that species are consistent in size and shape, and their size is considerably greater than that of the seeds we are now considering. These are so small that they closely approach the lowest limit of size found among seeds of living palms. Another difference is that the chalazal scar in *S. eocenica* is longer and more spathulate, narrowing at the basal end more gradually than it does in the species we are now discussing, to which we have given the name *Palmospermum minimum*. We cannot suggest an alliance with a living genus.

V. 22030 Holotype, figured Pl. I, figs. 30, 31. The cast of a seed with the testa largely abraded.
V. 22031 A second specimen.
Both specimens are Reid & Chandler Coll., Minster, 1929.

Palmospermum pusillum n. sp.

Plate I, figs. 32–34.

Diagnosis.—Seed extremely small, ruminate, concavo-convex, the ventral hollow being occupied by the raphe and chalaza; hilum marked by beak-like prominence. Position of embryo doubtful; testa of small polygonal cells.

Holotype.—V. 22032.

Description.—*Seed:* Extremely small, ruminate, somewhat compressed dorsi-ventrally, convex on the dorsal surface and concave on the ventral. The ventral chalazal cavity is large and circular except where the rim is interrupted by a wide shallow channel for the raphe; the position of the hilum is marked by a slight beak (Pl. I, figs. 32–34). The ventral cavity is partly filled by the remains of the parenchymatous chalazal thickening. The position of the embryo is doubtful, as will be explained, but it seems to have been lateral near the hilar end. The ruminations (seen only in one specimen) diverge from the margin of the chalazal depression and converge towards the hilum. Testa formed of small polygonal cells about 0·02 mm. in diameter. Length of holotype, 4 mm.; breadth, 4 mm.; thickness, 3·5 mm. Length of a second specimen, 4·5 mm.; breadth, 3·4 mm.; thickness, 2·5 mm.

Remarks.—Eight specimens found by ourselves at Minster in 1929. Only one shows a scar which may represent the embryo (Pl. I, fig. 34). This scar, which lies laterally near the hilum, is circular, with smoothly incurved margins, and has all the appearance of an embryo-scar. Unfortunately the impressions of the cells in its neighbourhood are not preserved, so we cannot tell whether or not they are arranged radially around it. Again, there is another scar lying at the end of the raphe canal in a position possible for an embryo, but it is oval (perhaps owing to distortion) and its margin is not so accurately curved as is usual in the embryo-scars of palms; also it is not depressed below the general level of the surface, but this may be an accident of preservation. The testa cells appear to radiate from its margin, but as they are polygonal and equiaxial this arrangement may again be more apparent than real.

Affinities.—The seeds are those of a species of palm. They are exceptionally small but lie just within the limit of size found among living palm seeds. We have not been able to discover their nearest living ally. We have named the species *Palmospermum pusillum*.

V. 22032 Holotype, figured Pl. I, figs. 32, 34. Seed with testa almost completely abraded. It may possibly show the embryo-scar.

V. 22033 Figured Pl. I, fig. 33. A longer, more slender specimen.

V. 22034 Five specimens, one now fractured longitudinally to show the chalazal plug.

V. 22035 A specimen which shows clearly the cells of the testa. These were protected by a thin coat of pyrites, now removed, over the dorsal surface.

The above are all Reid & Chandler Coll., Minster, 1929.

Palmospermum sp. 6

Plate I, figs. 35, 36.

Description.—*Seed:* Non-ruminate, originally sub-globular (now much distorted) with a long, broad, deep, ventral concavity nearly circular at the chalazal end, narrowing at the hilar end (Pl. I, fig. 35). The embryo-scar is a depressed, circular area, adjacent to, but not contiguous with, the hilar end of the concavity (Pl. I, fig. 36). A few small cells can be distinguished near the hilum, but the surface of the cast is almost entirely destroyed. The concavity was no doubt originally filled by a thickened raphe and chalaza-scar as in many palm seeds. Length of cast (distorted), 5 mm.; breadth, 5·5 mm.; thickness, 5 mm.

Affinities.—The specimen is undoubtedly a palm seed, but is too worn and distorted for specific diagnosis. It is clearly, however, distinct from any species previously described. It is the internal cast of the testa, and has been crushed and worn on the dorsal side in the neighbourhood of the chalaza so that the original shape has been destroyed.

V. 22036 Figured Pl. I, figs. 35, 36. A much distorted seed. *D. J. Jenkins Coll.*, Herne Bay, 1929.

Palmospermum (?) sp. 7

Plate I, figs. 37, 38.

Description.—*Seed:* Sub-globular, depressed dorsi-ventrally, internal surface of testa smooth and shining, very finely striate, the striations on the ventral face radiating from the hilum; ventral depression circular, ampulliform, very deep, filled with loose parenchymatous tissue (Pl. I, fig. 38). Embryo-scar not visible. Diameter of seed, 8·5 mm.; thickness, 6 mm.

Remarks.—Three internal casts of seeds found by ourselves at Minster in 1929. All had the general form of palm seeds, but except for a radial crumpling of the ventral surface from a central boss, they showed no indication of a hilar or chalazal depression. We therefore sectioned the specimens, thereby exposing the deep ampulliform hollow associated with the hilum and chalaza.

Affinities.—In general form and aspect, these seeds undoubtedly suggest a relationship to the Palmae, and in the depth of the ventral depression they somewhat resemble the seeds of *Livistona australis* Mart. The inner surface of the testa in *L. australis* is striate, but it is folded into countless minute corrugations. The embryo-scar is on the middle of the dorsal surface. In the larger of the two fossils there is a sub-hemispherical depression at this point which, however, has no definite outline such as limits the embryo-scar in palms. We cannot, therefore, feel satisfied that the dorsal depression marks the position of the embryo-scar. The fossil seeds of palms are nearly always represented by internal casts, hence unless the cast is sharp the impression of the scar may not show. The seed described has apparently shrunk and contracted around this dorsal depression; possibly, therefore, the scar does not show on this account. The smaller specimen is less well preserved. It also shows no embryo-scar. The evidence is such that we cannot feel certain that the specimens are palm seeds, although their characters suggest strongly that they may be.

V. 22037 Figured Pl. I, figs. 37, 38. A seed now broken to show the deep ventral infold.
V. 22038 A second seed, fractured into three pieces.
V. 22039 A third seed, now fractured.
The above are all Reid & Chandler Coll., Minster, 1929.

Palmospermum (?) sp. 7 (?)

Plate I, figs. 39–43.

1879. *Diospyros eocenica* Ettingshausen (pars.), p. 394.

Description.—*Seed:* Sub-globular, but flattened laterally by distortion, with a deep ventral depression (Pl. I, fig. 40) now filled with decayed loose-textured carbonaceous tissue. The depression is associated in one specimen (Pl. I, figs. 41, 42) with a distinct, somewhat flattened, circular organ from the centre of which the cells radiate. The testa is thin, about 0·15 mm. thick where preserved in a crumple of the surface; the surface shows everywhere the impression of polygonal cells, 0·016 mm. in diameter, which are nearly equiaxial except around the margin of the ventral depression, where they are rather more elongate with a tendency to be aligned in rows. Length of seed, 8·5 mm.; greatest diameter, 11·5 mm.; least diameter, 8·5 mm.

Remarks.—Two internal casts. From the specimen figured, Pl. I, figs. 41–43, a superficial plug came away from the ventral hollow, which showed, on its inner surface, the remains of a circular scar with a central organ; immediately beneath the plug was a gap and then came a mass of loose tissue. The form of the specimens suggest that they may be palm seeds, but we are uncertain of their relationship since they show no trace of an embryo-scar. They closely resemble the seeds described as *Palmospermum* sp. 7, and should perhaps be referred to that species.

V. 22040 Figured Pl. I, figs. 39, 40. A seed-cast from which the plug has come away so as to expose the deep ventral hollow.
V. 22041 Figured Pl. I, figs. 41–43. A second specimen with part of the ventral plug preserved The specimen is now fractured.
Both were in a jar with other fruits labelled by Ettingshausen "*Diospyros eocenica.*" *Bowerbank Coll.*, Sheppey.

Family NIPACEAE

Genus NIPA Thunberg

1782. Vet. Akad. Nya Handl. Stockh., iii, p. 231.

Nipa Burtini (Brongniart)

Plate II, figs. 1–6.

1784. *Cocos* Linnaeus: Burtin, p. 118, pl. xxx, fig. A.
1804. *Cocos* Linnaeus: Parkinson, p. 458, pl. vi, figs. 5–7; pl. vii, figs. 1–5.
1828. *Cocos Burtini* Brongniart, p. 121.
1828. *Cocos Parkinsonis* Brongniart, p. 121.
1828. *Pandanocarpum oblongum* Brongniart, pp. 135, 138.
1837. *Pandanocarpum* Brongniart: Endlicher, p. 244.
1837. *Burtinia* Endlicher, p. 257.
1838. *Cocites Burtini* (Brongniart) Bronn, p. 861.
1838. *Cocites Parkinsonis* (Brongniart) Bronn, p. 861.
1840. *Nipadites umbonatus* Bowerbank, p. 9, pl. i.
1840. *Nipadites ellipticus* Bowerbank, p. 11, pl. ii, figs 1–3.
1840. *Nipadites crassus* Bowerbank, p. 12, pl. ii, figs. 4, 5.
1840. *Nipadites cordiformis* Bowerbank, p. 13, pl. ii, figs. 6–10.
1840. *Nipadites pruniformis* Bowerbank, p. 14, pl. ii, figs. 11, 12.
1840. *Nipadites acutus* Bowerbank, p. 14, pl. iii, figs. 1–3.
1840. *Nipadites clavatus* Bowerbank, p. 15, pl. iii, figs. 4–6.
1840. *Nipadites lanceolatus* Bowerbank, p. 16, pl. iii, figs. 7, 8.
1840. *Nipadites Parkinsonis* (Brongniart) Bowerbank, p. 16, pl. iv.
1840. *Nipadites turgidus* Bowerbank, p. 21, pl. v.
1840. *Nipadites giganteus* Bowerbank, p. 22, pl. vi, fig. 1.
1840. *Nipadites semiteres* Bowerbank, p. 23, pl. vi, figs. 2–4.
1840. *Nipadites pyramidalis* Bowerbank, p. 24, pl. vi, figs. 5, 6.
1844. *Nipadites lanceolatus* Bowerbank: Mantell, p. 178, fig. 42^{9}.
1844. *Nipadites cordiformis* Bowerbank: Mantell, p. 178, fig. 42^{10}.
1845. *Nipadites umbonatus* Bowerbank: Unger, p. 180.
1845. *Nipadites ellipticus* Bowerbank: Unger, p. 180.
1845. *Nipadites crassus* Bowerbank: Unger, p. 180.
1845. *Nipadites cordiformis* Bowerbank: Unger, p. 181.
1845. *Nipadites pruniformis* Bowerbank: Unger, p. 181.
1845. *Nipadites acutus* Bowerbank: Unger, p. 181.
1845. *Nipadites clavatus* Bowerbank: Unger, p. 181.
1845. *Nipadites lanceolatus* Bowerbank: Unger, p. 181.
1845. *Nipadites Parkinsonis* (Brongniart): Unger, p. 181.
1845. *Nipadites turgidus* Bowerbank: Unger, p. 181.
1845. *Nipadites giganteus* Bowerbank: Unger, p. 181.
1845. *Nipadites semiteres* Bowerbank: Unger, p. 181.
1845. *Nipadites pyramidalis* Bowerbank: Unger, p. 181.
1845. *Burtinia cocoides* "Endlicher": Unger, p. 187.
1849. *Nipadites Burtini* (Brongniart): Brongniart, p. 88.
1849. *Nipadites Parkinsonis* (Brongniart): Brongniart, p. 88.
1849. *Nipadites ellipticus* Bowerbank: Brongniart, p. 88.
1850. *Nipadites* spp. (as Unger 1845): Unger, pp. 327–329.
1852. *Nipadites Burtini* (Brongniart): Lyell, p. 345, pl. xix, figs. 1, 2; pl. xx, figs. 7, 8.
1852. *Nipadites lanceolatus* Bowerbank: Lyell, p. 346, pl. xix, figs. 3, 4.
1852. *Nipadites Parkinsonis* (Brongniart): Lyell, p. 346, pl. xix, figs. 5, 6.
1852. *Nipadites Bowerbankii* Ettingshausen, p. 8.
1852. *Nipadites semiteres* Bowerbank: Ettingshausen, p. 8.
1852. *Burtinia cocoides* "Endlicher": Ettingshausen, p. 9.

1852*a*. *Nipadites Bowerbankii* Ettingshausen: Ettingshausen, p. 491.
1852*a*. *Nipadites semiteres* Bowerbank: Ettingshausen, p. 492.
1853. *Palmocarpon cretaceum* Miquel, p. 51, pl. vii.
1853. *Palaeokeura Pellegriniana* Massalongo, p. 13.
1855. *Palaeokeura Pellegriniana* Massalongo, p. 21, pls. i–iv.
1858. *Fracastoria melo* Massalongo, p. 36.
1859. *Palaeokeura Pellegriniana* Massalongo: Massalongo, p. 33.
1859. *Fracastoria melo* Massalongo: Massalongo, p. 86.
1859*a*. *Fracastoria melo* Massalongo: Massalongo, p. 81, pl. xxix.
1866. *Nipadites Heberti* Watelet, p. 92, pl. xxix, figs. 2, 3.
1870. *Nipadites Burtini* (Brongniart): Schimper, p. 479.
1870. *Nipadites Parkinsoni* (Brongniart): Schimper, p. 480.
1870. *Nipadites semiteres* Bowerbank: Schimper, p. 480.
1870. *Nipadites Heberti* Watelet: Schimper, p. 480.
1871. *Nipadites ellipticus* Bowerbank: Lyell, p. 239, fig. 205.
1874. *Fracastoria melo* Massalongo: Schimper, p. 609.
1879. *Nipadites* cf. *crassus* Bowerbank: Gardner, p. 221.
1879. *Nipa Burtini* (Brongniart) Ettingshausen, p. 393.
1879. *Nipa elliptica* (Bowerbank) Ettingshausen, p. 393.
1879. *Nipa lanceolata* (Bowerbank) Ettingshausen, p. 393.
1879. *Nipa Parkinsonis* (Brongniart) Ettingshausen, p. 393.
1879. *Nipa semiteres* (Bowerbank) Ettingshausen, p. 393.
1879. *Amomum sheppyense* Ettingshausen, p. 393.
1879. *Amomum stenocarpum* Ettingshausen, p. 393.
1883. *Nipa Burtini* (Brongniart): Schmalhausen, p. 294, pl. iii (xxx), figs. 2–6.
1892. *Palaeokeura Pellegriniana* Massalongo: Meschinelli & Squinabol, p. 161.
1892. *Fracastoria melo* Massalongo: Meschinelli & Squinabol, p. 335.
1894. *Nipadites Burtini* (Brongniart): Rendle, p. 149, pl. vi.
1894. *Nipadites Parkinsonis* (Brongniart): Rendle, p. 150, pl. vii, figs. B, C.
1894. *Nipadites lanceolatus* Bowerbank: Rendle, p. 151, pl. vii, fig. A.
1894. *Nipadites umbonatus* Bowerbank: Rendle, p. 152.
1894. *Nipadites cordiformis* Bowerbank: Rendle, p. 152.
1894. *Nipadites ellipticus* Bowerbank: Rendle, p. 153.
1894. *Nipadites Heberti* Watelet: Rendle, p. 153.
1894. *Nipadites acutus* Bowerbank: Rendle, p. 154.
1897. *Nipadites Burtini* (Brongniart): C. Reid, p. 6, fig. 11 on p. 7.
1903. *Nipadites Heberti* Watelet: Fritel, p. 172, fig. 184; pl. xxix, figs. 3, 4.
1903. *Nipadites Burtini* (Brongniart): Seward & Arber, p. 9, pl. i, figs. 2, 3; pl. ii, figs. 5–7, 10, 11.
1904. ?*Nipadites Sickenbergeri* Bonnet, p. 499, figs. on pp. 500, 501.
1917. *Nipadites Parkinsoni* (Brongniart (?)): Osborne White, pp. 31, 32.
1921. ?*Nipadites* cf. *Burtini* var. *giganteus* Bowerbank: Fritel, p. 317, pl. xvi, fig. 1.
1921. *Nipadites Burtini* (Brongniart) var. *giganteus* Bowerbank: Fritel, p. 317, pl. xvi, fig. 2.
1921. *Nipadites Burtini* (Brongniart): Fritel, p. 317, pl. xvi, fig. 3.
1927. *Nipadites Burtinii* (Brongniart): Kryshtofovich, p. 639, pl. xv.

DIAGNOSIS.—Inflorescence a capitulum (by inference). Fruit a one-loculed, one-seeded drupe, obovoid, umbonate, angled below, of very variable size. Carpel wall thick, especially at the domed apex; epicarp thin; sarcocarp formed of fibres embedded in parenchyma; endocarp, pierced at the base by a large aperture through which germination takes place, formed of an outer coat of longitudinal fibres interwoven with matted transverse fibres, and an inner coat of compact longitudinal fibres. Seed large, globular, not, or but rarely, grooved. Testa thin.

HOLOTYPE.—V. 21762. Middle Eocene, Brussels (Porte de Louvain). Figured Burtin, 1784. *Van Breda Coll., purchased* 1871.

DESCRIPTION.—*Fruits:* One-loculed, one-seeded, growing in a fruiting head (by inference from their form and structure compared with that of the living *Nipa*) the drupes being in contact for more than half their length, as indicated by the faceting of the lower end (cf. Bowerbank, 1840, pl. i, figs. 6, 9). Form and size of fruit very variable, depending on the degree of development and the position in the fruiting head, obovoid, or sometimes greatly elongate, usually compressed, faceted below, the number of facets varying from two to six; apex more or less umbonate. Carpel wall thick, especially at the apex, where it is so greatly developed that it is frequently preserved when the rest of the fruit has perished.

Epicarp probably thin and smooth, but the external cells are almost invariably decayed.

Sarcocarp thick, greatly thickened at the apex, formed of large longitudinal fibro-vascular bundles embedded in a mass of loose parenchymatous tissue (the whole much impregnated with pyrites), fibres spirally thickened.

Endocarp of fairly uniform thickness, formed of two coats: the inner composed of compacted longitudinal fibro-vascular bundles; the thinner outer coat of larger longitudinal fibro-vascular bundles much more widely spaced, and interwoven with a matted mass of finer fibres of which the general trend is transverse (Pl. II, fig. 2). The endocarp is pierced at the base by a large aperture which serves to admit the nutrient fibres and to allow of the egress of the embryo in germination (Pl. II, fig. 5). Maximum length of fruit (according to Bowerbank, who had access to a larger suite of specimens than is now available), 7 inches [180 mm.] in *Nipadites giganteus* Bowerbank; breadth, ½ to 4½ inches [13 to 120 mm.].

Seed: Large, globular or compressed, occasionally showing a very shallow longitudinal groove which does not extend to the apex (Pl. II, fig. 4). Testa thin, usually adhering to the endocarp; internal surface with a meshwork of ridges, the ridges being more or less transverse. On the cast of the seed-cavity (the entity usually preserved) these produce a marked pattern over the surface (Pl. II, figs. 4, 6. N.B.—Figure 6 is turned through a right-angle so that the horizontal ridges lie vertically). The cells of the internal surface of the testa are small and polygonal or quadrangular. Length of seed (Bowerbank's measurements), about 35 to 89 mm.; breadth from 23 to 70 mm. We have seen some seeds which are thin and flat; perhaps the result of crushing or imperfect development, and others which are approximately half the size of Bowerbank's smallest specimens, one specimen, for example (V. 22052), being 20 mm. long and 13 mm. broad.

REMARKS.—*Nipa* fruits, or more often fragments of fruits, outnumber any other fossil species found at Sheppey. They are strewn in great abundance wherever the dark patches of pyrites nodules occur (see Introduction, p. 23). Every stage of abrasion is represented, as is also every degree of development prior to fossilization. By far the greater number of the fruits are small and immature (Pl. II, fig. 3), although some small fruits contain well-developed nuts while many of the larger fruits are abortive. These facts are probably to be explained by the latitude in which the fossils occur, because, so far as is at present known, Sheppey represents the northern limit of the genus. Neither the abortive nor the immature specimens show, when sectioned, any trace of a nut, but are composed throughout of spongy parenchyma and fibres as in similarly undeveloped living specimens. Over 200 specimens are catalogued, and this represents but a fraction of the number which could have been collected at Sheppey even during a brief visit.

Affinities.—Like other palaeobotanists who have studied the fossil fruits commonly known as *Nipadites*, we have reached the conclusion that these Sheppey fruits find their nearest living ally in the genus *Nipa*. The only other similar fruit known to us is *Pandanus*. In this latter large genus, the fruits may be either multi- or uni-locular, the multilocular fruits alone being comparable in size with the larger fossil specimens of *Nipa*; the unilocular fruits being very much smaller. The fruits of *Pandanus*, moreover, are not compressed, and beneath the apex, within the substance of the sarcocarp, is a large cavity filled with loose pithlike material. We have seen no evidence of such a cavity in the fossils, and the bundles of fibres permeate the sarcocarp throughout. This observation is in accordance with that of Dr. R. Kräusel (1923, p. 77), who also found no hint of a cavity such as occurs in *Pandanus*. Further, in *Pandanus* the seeds are more elongate, and narrower. Comparison between the two genera *Nipa* and *Pandanus* therefore indicates that the alliance of the fossil is with *Nipa*.

In the detailed comparison between the Sheppey fossil species and *Nipa* which now follows, we will first discuss the points of agreement, and afterwards the points of difference. The recent material upon which our comparison is based comprises a wide range of fruits, including drift fruits, preserved in the Kew Herbarium and the museums of the Royal Gardens at Kew, also a large number of specimens, including a complete head kindly sent by Mr. Holttum, the Director of the Singapore Gardens, at the request of Mr. I. H. Burkill. We have also been able to avail ourselves of much valuable information supplied by Mr. H. N. Ridley from his knowledge of the living plants in their native habitat.

The points of resemblance between the Sheppey fruits and Nipa are :—

(1) The general shape and the degree of variation in shape. In both, the drupes are obovoid. Below, they are faceted and taper towards their base; above, they are dome-shaped, and (when perfect) umbonate. In both, attenuation of form may result from mutual pressure, or lack of development. The faceting in the recent fruits is the result of mutual pressure, and doubtless was so in the fossil species also. In living fruits which have drifted in the sea the angles become worn, or may even be obliterated. The absence of facets in many of the fossil fruits is doubtless primarily to be attributed to the same cause, although the effect has been greatly enhanced by abrasion on the foreshore at Sheppey. Consequently the Sheppey fruits are frequently less faceted than the living.

(2) The size, and variation in size, are much the same in fossil and living fruits. In both, the degree of variation is very great, and in the living there are usually considerable differences between the individual fruits of a single head. The recent fruits show almost as great a range as those from Sheppey; there are larger specimens among the latter, but the smallest fossils are equalled by recent fruits from Ceylon in Kew Herbarium (C.N. 3333), which are only 18 mm. in length. The largest fruit of *N. fruticans* in our own collection measures about 135 mm. (the base is frayed out). The variation in size among living specimens depends not only on

the position in the fruiting head, but also on the degree of maturity and development. It is to be noted in this connexion that the specimens referred by Ettingshausen to *Amomum* (V. 22084) are merely immature specimens of *Nipa*, as is evidenced by the characteristic fibrous and parenchymatous tissue.

(3) The character of the carpellary coats and of the testa is the same in the Sheppey fossils and the living *Nipa*. (*a*) In the fossils the epicarp, according to Bowerbank, " is thin and smooth, presenting occasionally a faint impression of the bundles of vessels which ran beneath it." The only fragments seen by us bear out this description. Such an appearance is in full agreement with that of *N. fruticans* when the hard shining epidermis is worn or macerated, as not infrequently happens, especially in drift fruits. (*b*) The sarcocarp in both fossil and recent fruits is composed of loose spongy tissue in which coarse longitudinal fibro-vascular bundles are embedded, the fibres being spirally thickened. In both, it is greatly developed at the apex of the fruit but is thinner along the sides. In the fossils the wall tends to break transversely where it is thin over the middle portion of the fruit, leaving the dome-shaped cap adhering to the seed-cast. (*c*) The endocarp is identical in structure both in the living and fossil fruits. It is formed of two coats, an inner coat composed of longitudinal fibres only, and an outer coat of longitudinal fibres interlaced with transverse fibres. As compared with the sarcocarp the endocarp is thin ; it is of fairly uniform thickness. When freed from the adhering testa by natural decay, the locule in the living fruit presents the same smooth surface with embedded fibres as is frequently seen in the fossil. (*d*) The testa of *Nipa fruticans* is thin and papery and on its inner surface shows a coarse raised network of transversely elongate meshes, corresponding in form with the transverse ornamentations of the fossil seed, which clearly represent the impressions of similar meshes. Also the cells lining the testa form fine polygonal pits which correspond with the raised impression of similar cells on the casts of the testa in the fossil.

(4) The general form of the developed seeds and their size are on the whole remarkably alike in the living material and the Sheppey fossils, although there is a difference to which we must refer later.

(5) The mode of germination was obviously the same in the fossil as in the living. The fibres at the base of the drupe decay, allowing the embryo egress through the large basal aperture. In the fossil the cavity left after germination has frequently been filled by mud which forms an internal cast of the testa.

The points of difference are :—

(1) Slight differences in the faceting of the base. The fossils show fewer, larger, and more rounded ribs, with shallower re-entrant angles. But it is possible that the more rounded contours may in part be due to abrasion either before or after fossilization which has smoothed the sharp angles and rendered the depressions shallower. That abrasion may have had this effect, is demonstrated by the occasional absence of the sarcocarp, the endocarp alone remaining.

(2) Differences in the shape of the domed head. Since the domed heads are free, not being contiguous in adjacent fruits, these differences must be regarded as more truly specific than differences in the faceting of the base. Both broad and

sloping forms are found in the fossil as well as in the recent, but whereas broad forms preponderate in the living species, sloping forms preponderate in the fossil. This again may be, in some slight measure, the result of abrasion, and it is of interest to note, therefore, that among the Belgian specimens of *Nipadites Burtini* figured by Seward and Arber (1903, pl. 1, fig. 2; pl. ii, fig. 11) two especially well-preserved specimens (as indicated by the sharpness of their facets) show forms as rounded as those of the average living fruits. But these specimens are clearly much less abraded than the Sheppey fruits.

(3) The chief difference, however, between the fossil and living species lies in the poor development (usually amounting to complete absence) in the fossil, of the longitudinal ridge of the endocarp which projects into the locule in the living fruit, and of the corresponding longitudinal sulcus in the seed. In *Nipa fruticans* ridge and sulcus are constant and conspicuous. In *N. Burtini*, according to our observations, they are scarcely ever seen, but we have found two specimens which show traces of them, although even in these they are very slight and are not continued to the apex (Pl. II, fig. 4). There is some evidence in support of the possibility that the absence of the ridge in the endocarp may be due in part to decay prior to fossilization, for in a much worn drift fruit of *N. fruticans* in the carpological collection of Kew Herbarium it seems to have disappeared completely. But it is probable that the difference in the development of ridge and sulcus in the fossil and recent fruits is specific.

To sum up the evidence: It is quite clear that the Sheppey fossil species and the living *Nipa* are closely related, the relationship being shown even in minute details of structure. But they are not identical. Therefore they cannot be placed in the same species. The question arises whether they can be placed in the same genus. We have no means of discovering directly what generic variation implies in the family Nipaceae, for *Nipa* is monotypic. All we can state is that as compared with the degree of variation seen in members of the closely allied family Palmae, the variations should be considered as specific rather than generic. In our opinion, therefore, the Sheppey fossils should be referred to the living genus *Nipa*.

Nipa fruticans Thunb. is confined to the tropics of eastern Asia. It is a small stemless palm which grows in dense masses along the tidal waters and in the mangrove swamps of India, Ceylon, the East Indies, the Malay peninsula, the Philippines, Australia, and New Guinea. The nuts are constantly seen floating on the water in these regions. Thus in the delta of the Ganges, Hooker observed them in such numbers as to obstruct the paddle-wheels of steamboats (Lyell, 1871, p. 239).

It is necessary now to review the grounds upon which previous workers have preferred to place the fossil in a separate genus *Nipadites*, and to point out, as far as possible, how the apparent differences on which they based their decision can be accounted for.

Bowerbank states (1840, p. 8) that " the resemblance existing between the whole of the species of *Nipadites*, both as regards their external form and their internal structure, with those of *Nipa*, is so close as to leave scarcely a doubt of their being members of the same genus, the only difference being that the recent fruit has the interior surface of the pericarp [the endocarp] somewhat in a state of induration, which is not perceptible in that of any of the fossil species, although it may have been so to a considerable extent in their original state, . . . And when we take into consideration the great variation in different species in the degree of thickness of the bony endocarp of the nearly-allied genus *Cocos*, we can scarcely consider this single discrepancy sufficient to remove the fossil from the recent genus. I have therefore thought it advisable . . . to apply . . . [the name] *Nipadites*, as . . . expressive of their true relation to their recent analogues." This is a perfectly valid reason, founded so far as his knowledge went on a structural difference, and, if supported by fact, necessitating such a separation. But, as stated on pp. 120, 122, we have now recognized the indurated endocarp. Hence Bowerbank's one reason for keeping the Sheppey fossils distinct from *Nipa* disappears.

Schimper (1870, p. 479) thought it probable that the Sheppey fruits belonged to the genus *Nipa*, but he had not the courage of his opinions and described them as *Nipadites*.

Dr. A. B. Rendle (1894, p. 144), reviewing Bowerbank's reference of the fossil to the genus *Nipadites*, states his conclusions in the following words: "So near in fact, is this relation, [to the recent genus *Nipa*] that one is tempted to follow Ettingshausen, who in a list in the *Proceedings of the Royal Society*, xxix, p. 393, reduces all the species to *Nipa*. The only consideration which leads me to keep up the palaeontological suffix is the uncertainty which must always attach to the specific diagnosis of fossils, based, as it often necessarily is, on material which would be deemed quite inadequate in the case of recent plants." Dr. Rendle's objection to placing the species in the genus *Nipa*, is quite different from Bowerbank's, and it is worth examining his statement in detail because it embodies a very common attitude of the recent botanist towards the study not only of fossil, but also of living, fruits and seeds. It opens with the remark that the resemblance between living and fossil is so close as to suggest that they should be united in one genus. Then follows the implied reflection that no botanist would dare to diagnose a recent plant of *Nipa* from its fruit alone. We can scarcely believe that any botanist who had made as comprehensive a study of fruits as he had of floral organs, would hesitate for a moment to determine *Nipa* from a fully developed drupe. There is no other drupe like it.

Seward and Arber (1903, p. 7), in referring to Ettingshausen's use of the name *Nipa* rather than *Nipadites*, state "tout en reconnaissant la ressemblance frappante entre les types tertiaires et le type encore existant, nous restons convaincus que le meilleur parti est le maintien de la dénomination proposée par Bowerbank, parce qu'elle exprime le fait que les spécimens ne sont pas récents, mais fossiles et que, en outre, elle ne nous engage pas par l'admission définitive d'une identité générique qui n'a pu être prouvée."

Behind this statement there lurks the same doubt as influenced Dr. Rendle in his decision. But when the differences between fossil and recent fruits are so slight as to correspond with specific rather than with generic differences among living plants, it is a mistake to adopt a nomenclature which suggests a generic, not a specific, difference. It implies a greater break in phylogeny than is warranted by the facts.

We have now to consider the number of species of *Nipa* represented in the London Clay of Sheppey. Bowerbank divides the Sheppey fruits into thirteen species. In view of the great value and importance of his pioneer work, and of the further evidence as to the causes of variation in form which we have been able to adduce, we must review shortly his reasons for multiplying species, in the light of our own observations. His diagnostic characters are the following :—

(1) *Number of angles.*—A single head of the living *N. fruticans* may show a greater variation in the number of angles (due to mutual pressure) than is shown by the London Clay fruits as now abraded.

(2) *Degree of compression.*—This is the consequence of mutual compression and arrested development.

(3) *Presence or absence of an umbo.*—Variation in the size, and straight or bent character of the umbo is found among living drupes ; in drifted fruits the umbo may be completely worn away, or it can be worn away after fossilization, by abrasion.

(4) *Variation in form whether of base or of free apex.*—This has already been dealt with in great detail, and it has been shown that variation in the form of the base is generally due to abrasion, either before or after fossilization, whereas variation in the shape of the free apex corresponds mainly with individual differences such as occur in the drupes of *N. fruticans*, although it may be modified to a slight extent by abrasion. Under this head we may note that Bowerbank's species *Nipadites ellipticus* and *N. cordiformis*, in especial, show very marked differences due to abrasion, differences which are seen in a lesser degree in most of his species.

(5) *Character of the epicarp.*—The apparent differences in the character of the epicarp, as we have already seen, are due to differences in the degree of abrasion.

(6) *Character of the sarcocarp.*—This also depends on the degree of abrasion which may expose either the true sarcocarp or the endocarp. Bowerbank did not distinguish between these two coats, but called both the sarcocarp.

(7) *Character of the testa, smooth or "corrugated."*—Bowerbank's "seed" is not the true seed, but an internal cast of the testa. The character of the surface therefore depends upon the fineness of the impression. When very perfect, the cast shows the characteristic ornamentation (corrugations) of the interior of the testa, when less perfect the corrugations are not impressed and the surface is smooth.

(8) *Size.*—The size of drupes, as we have seen, is variable in the living, and the variation in size of the Sheppey fossils only corresponds with similar variation in the living.

Hence it appears that Bowerbank's diagnostic characters have no specific value, but are either due to individual variation, or to differences resulting from the degree of abrasion that has taken place, before or after fossilization.

Subsequent workers have usually reduced the number of his species in a greater or lesser degree on the grounds that the drupes in the living species are variable. Schimper (1870, p. 480) reduced the number to three. Ettingshausen's last list (1879, p. 393) gives five species which he definitely refers to *Nipa* but without any descriptions or discussion in support of this determination. Rendle (1894, p. 143), after a considered review of the evidence, reduced the Sheppey fossils to six species. Seward and Arber (1903, p. 1) and Fritel (1921, p. 317) do not enter into any critical study of the Sheppey fruits as a whole.

In our own opinion all the various fossil fruits from Sheppey are identical in structure, form a connected series, and are related in precisely the same way as are similar forms in the one living species. Consequently we conclude that only one fossil species is represented at Sheppey, and this species appears to be inseparable from *Nipa Burtini* (Brongniart) from the Eocene of Belgium (cf. Lyell, 1852; Seward and Arber, 1903; Fritel, 1921).

Previous Records.—In considering references to fossil species of *Nipa* we have endeavoured to make the list as complete as possible, but critical study of all the actual specimens referred to the genus is beyond the scope of the present volume.

The earliest record appears to be by Parsons in 1757, who published an account of fossil fruits found in Sheppey by Edward Jacobs. Among his figures there is one showing a kernel of *Nipa* which he describes as a stone of the "eastern mango" (1757, p. 396, pl. xvi, fig. 4). Dr. Rendle also regarded two others of Parsons' figures (pl. xv, figs. 1, 3) as representing *Nipa*, but after handling much material from Sheppey we can state with confidence that they merely represent either woody nodules or bored wood.

In 1781 (p. 448, pl. v, fig. d) W. Jones figured a *Nipa*, describing it as some species of cocoanut.

In 1784 (pl. xxx, fig. A) Burtin figured as *Cocos* a specimen from the Eocene of Brussels, now in the British Museum (V. 21762), on which Brongniart later instituted the species *Cocos Burtini*.

In 1785 James Douglas, in "A Dissertation on the Antiquity of the Earth," figured a *Nipa* from Sheppey (p. 25), which he regarded as a species of almond.

In 1801 T. Pennant reproduced one of Parsons' figures of *Nipa* (p. 88, fig. 3 of plate).

In 1804 Parkinson figured several specimens of *Nipa*, referring them to *Cocos* sp. Pl. vi, fig. 6 represents a *Nipa* kernel, fig. 5 of the same plate may also represent a crushed *Nipa*. Pl. vii, figs. 1, 2, 4, 5, represent fruits, and fig. 3 another kernel. Of these figures, figs. 4 and 5 represent a specimen previously figured by Douglas in 1785.

In 1810 Francis Crow illustrated numerous fruits and seeds of *Nipa*, in a manuscript catalogue which is now in the British Museum of Natural History.

In 1828 Brongniart (p. 121) named the Belgian specimen figured by Burtin *Cocos Burtini*, and Sheppey specimens figured by Parkinson *Cocos Parkinsonis;* on pp. 135, 138 he described some of the Sheppey specimens as *Pandanocarpum oblongum*.

In 1837 Endlicher (p. 257) instituted a new genus, *Burtinia*, for the Belgian and Sheppey fruits, but without mentioning any species.

In 1838 Bronn (p. 861) listed Brongniart's two species under the generic name *Cocites*.

In 1840 Bowerbank recognized that the closest affinity of these fossils was with *Nipa*, and from that time onwards, with few exceptions, the name *Nipadites* has been applied to these fruits. His specimens were mainly from Sheppey, but he also records a fruit from Primrose Hill (p. 15).

In 1849 (p. 88) Brongniart, recognizing that Bowerbank was right as regards the relationship of the Sheppey fruits, accepted the name *Nipadites* both for the Sheppey and Belgian specimens which he had previously listed under the generic name *Cocos*, and for the Sheppey material listed as *Pandanocarpum*. Brongniart states that many of Bowerbank's species represented merely varieties or individual differences.

In the third edition of the "Lethaea Geognostica" (1853, p. 116), Bronn also adopted Bowerbank's name *Nipadites*, but with the footnote "der Name ist nach *Nipa* ganz fehlerhaft gebildet, zumal kaum ein Grund vorhanden scheint, *Nipadites* von *Nipa* zu trennen."

Between 1852 and 1859 Massalongo described three new genera from Italy. He did not regard all these as related to *Nipa*, but Fritel has later so determined them (1921, p. 317). (1) The first of these genera is *Castellinia*, divided by Massalongo into seven species, six from Monte Bolca and one from Ronca. The references to Massalongo's work on *Castellinia* are as follows: 1852, pp. 206, 207; 1853, pp. 11, 12; 1858, pp. 26, 27, 56; 1859, pp. 36, 37. See also Schimper (1870, p. 481); Meschinelli and Squinabol (1892, pp. 162, 163); Fritel (1921, p. 317). (2) The second genus *Fracastoria* was divided into fifteen species distinguished from one another by differences in the size of fruit and pedicel, the largest being 60 cm. long, in addition to a pedicel of 8 cm. Massalongo related it to the Sterculiaceae, but Fritel has since referred it to *Nipadites*. The genus *Fracastoria* was originally distinguished from *Castellinia* by the presence of a pedicel [apparently, in some specimens at least, the internal cast of the canal by which the vascular cord enters the fruit, and by which the embryo germinates]. Massalongo's work on *Fracastoria* will be found in the following: 1858, pp. 35–38; 1859, pp. 86, 87; 1859*a*, p. 81. See also Schimper (1874, pp. 608–610); Meschinelli and Squinabol (1892, pp. 333–335); Fritel (1921, p. 317). We have seen Massalongo's original photographs of *F. melo* and *F. lagenaria* (1859*a*, pls. xxix, xxx), and in our opinion the relationship of the latter is by no means clear from the photograph. In 1921 Fritel (pl. xvi, fig. 3) reproduced the former figure, which he designates "*Nipadites Burtini* Brong. (=*Fracastoria melo* Massalongo)." Fritel states that Massalongo's descriptions and remarks leave no doubt as to the identity of this fruit, and that his figure represents a specimen identical with Seward and Arber's *Nipadites Burtini*. To us, also, this figure seems definitely to represent a *Nipa* which is indistinguishable from *N. Burtini*. It follows, therefore, that some at least of the specimens described as *Fracastoria* by Massalongo belong to *Nipa*. (3) The third of Massalongo's genera, *Palaeokeura* (1855, p. 1, pls. i–iv), first referred to *Nipadites* by Massalongo himself, is represented by a single species and is shown by admirable figures to be identical with *N. Burtini*, an identity accepted by Rendle (1894), Seward and Arber (1903), and Fritel (1921).

In 1853 (p. 51, pl. vii) Miquel described and figured as *Palmocarpon cretaceum* a specimen which was stated to be from the Cretaceous of St. Pietersberg near Maastricht. This specimen is now in the British Museum (V. 21763), having been acquired with the Van Breda collection in 1871. It is undoubtedly an example of *Nipa Burtini*, but in matrix and preservation it is identical with Belgian Eocene specimens from Schaerbeek. There is little doubt that Miquel's ascription of this specimen to the Cretaceous was an error, especially as in the sale catalogue of the Van Breda collection other specimens of *Nipa* from Brussels, including that figured by Burtin, are also listed under the Cretaceous of Maastricht.

In 1866 (p. 92, pl. xxix, figs. 2, 3) Watelet described a species of *Nipadites* from the Paris Basin under the name *N. Heberti*. Fritel later (1903, p. 172, fig. 184; pl. xxix, figs. 3, 4) published some further figures of this species. Rendle (1894) stated that it is closely comparable with one of the Sheppey forms. In view of the connexion between the Paris and Belgian Eocene basins, it is probable that a single species inhabited the shore lines of both areas.

In 1870 (pp. 479, 480, 481, 608–610) Schimper summarized previous work. He reduced the number of Bowerbank's species, and united some of them with *Nipadites Burtini*. He accepted Massalongo's genera, but suggested that the species of *Castellinia* ought to be united into one.

In 1879 (p. 221) Gardner recorded a fruit of *Nipadites* from the Bracklesham beds of Bournemouth.

In 1883 Schmalhausen (p. 294, pl. iii [xxx], figs. 2–6) recorded fruits from the Eocene of Kiev under the name *Nipa Burtini*.

In 1894 Rendle monographed the genus under the name *Nipadites* (cf. p. 124), giving references to previous work. He published the first record of specimens from the Bracklesham beds of Hengistbury Head, Hampshire (p. 150), and West Wittering, Sussex (p. 150, pl. vi). He reduced the number of Bowerbank's species, and united some of them with *N. Burtini*.

In 1903 Seward and Arber monographed the Belgian material, referring the species to *Nipadites Burtini*; they give many references to previous literature.

In 1904 Bonnet (p. 499, figures on pp. 500, 501) described a species from the Middle Eocene of Egypt under the name *Nipadites Sickenbergeri*. Whilst stating that it resembled *N. Burtini* in form, he distinguished it from that species by characters of form and ribbing; characters which may or may not be specific.

In 1921 Fritel published an important paper on the genus *Nipadites* and on its geographical and stratigraphical distribution. He gives a complete list of French and Belgian localities. We have already referred to his opinion of Massalongo's Italian specimens, and the only further remark that we need make in regard to his work is that he figures a large fruit from Senegal, probably of Lutetian age, and in the description of his plate calls it *Nipadites* cf. *Burtini* var *giganteus* Bowerbank, stating in the text that it is near to *N. Burtini* if not absolutely identical with it.

In 1923 Dr. R. Kräusel (p. 77, pl. ii) described a species of *Nipadites* from the Eocene of Borneo, under the name *N. borneensis*. Judging by his illustrations the seeds have a more fluted form than those of *N. Burtini*.

In 1925 M. E. J. Chandler (p. 15, pl. ii) described a leaf of *Nipa* from the Upper Eocene of Hordle.

In 1927 Kryshtofovich (p. 639, pl. xv) described a *Nipa* fruit from Viosnesensk in south-western Ukraine on the Bug River. It was found in beds which are probably of Upper Eocene age, and described under the name *Nipadites Burtinii* Brongniart. More recently (1931, p. 275) the same author has recorded fruits from another Ukrainian Eocene locality, Kalinovka near Elisabethgrad.

Before leaving the records of literature dealing with fossil *Nipa* we must refer to certain American work. In 1914 (p. 57) and 1916 (p. 176, pl. cxii, figs. 13, 14) Professor Berry recorded a species which he named *Nipadites Burtini* Brongniart var. *umbonatus* Bowerbank, from the Wilcox Beds. The occurrence of *Nipa* in America would be of such importance that it is necessary to scan the evidence critically. The description (1916, p. 176) reads " Drupelike fruits of different sizes, ranging from 5 to 8 centimeters in length and from 3 to 5 centimeters in diameter, obovate in outline with a narrowed truncated base and a broadly rounded, umbilicate apex. Surface fibrous and obscurely angled." One of the two figures represents a flattened fruit (not umbilicate) lying in the matrix. The other is the drawing of a larger fruit, also flattened, but free from the matrix, it has an excentric umbo, and is represented with a curious lateral excrescence. Neither figure shows any angles, and the smooth surface is formed of a coat of longitudinal fibres with (in the smaller specimen) remains of another integument. We fail to see on what evidence the fruits are called drupe-like, as apparently they were not sectioned. Except that the one fruit is umbonate (a character not confined to *Nipa*) we can see nothing either in the description or figure that is especially distinctive of that genus.

In 1930 (p. 56) Professor Berry again referred a fruit, collected some years previously, to *Nipadites*. He believed that the specimen had come from the Wilcox Beds (Granada Formation) of Tennessee. His description is very slight but the material was evidently badly preserved. His three figures (pl. l, figs. 11–13) bear no relation to any *Nipa*, either fossil or living, that we have seen. The form is a nearly regular ovoid, without differentiation into a free apical portion, and narrow faceted basal portion. Moreover, the base, as he states " is truncate and slightly excavated and shows a thick rounded peduncular scar, about 5 millimetres in diameter." Such a base and basal scar we have never met with in a fossil *Nipa*. Moreover, when the living fruits are detached from the head the base frays so as to form a fringe of long coarse fibres ; in the Sheppey specimens these are cemented by pyrites when they have not been completely abraded. Even in speaking of the section as showing " a single-seeded central cavity " Professor Berry remarks truly, if we may judge by his fig. (pl. l, fig. 13), " these features may be illusory and purely fortuitous."

In 1931 Professor O. M. Ball (p. 149) applied Berry's description to a fruit from the Eocene of Texas, but gave no further description of his own. His figure (pl. xxiv, fig. 3) is even less convincing than those of Berry.

We cannot, therefore, accept the occurrence of *Nipa* in America as established.

Distribution.—From the above references to literature it will be seen that fruits referable to *Nipa* have been recorded from many parts of the world. In England from the London Clay of Sheppey, Shoeburyness, Essex (V. 12913, etc.), Primrose Hill (Bowerbank, 1840, p. 15), Highgate Archway (Prestwich, 1854, p. 415), Haverstock Hill (V. 7530), Portsmouth (Meyer, 1871, p. 77), Coldharbour Farm near Ewell and The Wrythe, Carshalton, Surrey (Dewey & Bromehead, 1921, p. 35), Clapham (A. G. Davis, 1928, p. 351), The Potteries, New Malden, Surrey (V. 22089). From the Bracklesham Beds of West Wittering, Sussex (Rendle, 1894, p. 150, pl. vi; C. Reid, 1897, p. 6, fig. 11, on p. 7), of Bournemouth (Gardner, 1879, p. 221; Osborne White, 1917, pp. 31, 32), of the New Forest (Gardner, 1887, p. 249), and of Hengistbury Head (Rendle, 1894, p. 150). A leaf of *Nipa* was also recorded from the Upper Eocene Hordle Beds (Chandler, 1925, p. 15, pl. ii).

In Belgium the fruits are known from the Lower to the Upper Eocene (as they are in Britain). They occur in the Upper Cuisian of Mont Panisel, Flobecq, and Thorout; in the Laekenian of Schaerbeek, near Brussels; in the base of the Ledian at Saint Gilles, near Brussels; and in the Wemmelian in the sands of Jette.

In France *Nipa* fruits occur in the grits of Belleu (Upper Cuisian), and in the Marls of Gau (Basses-Pyrenées); in the Middle and Upper Lutetian of Vauves and Issy, where they occur in the glauconitic limestone with *Cerithium giganteum;* and in the sandy Marls of Trocadero, Paris; also in the Bartonian of Noirmontiers (Loire Inférieur).

In Italy fruits which have been referred to *Nipa* occur at Monte Bolca and Ronca.

In Russia *Nipa* is known from the Eocene of Kiev, South Russia (Schmalhausen, 1883, p. 12, pl. iii, figs. 2–6), and from the Ukrainian Eocene at Viosnesensk (Kryshtofovich, 1927, p. 639, pl. xv), and Kalinovka (Kryshtofovich, 1931, p. 275).

In Egypt from the Nummulitic Beds (Lutetian) of the Mokattam Mountains, east of Cairo (Bonnet, 1904, p. 499).

In Senegal fruits of *Nipa* have been found with fish comparable to those of Monte Bolca (Fritel, 1921, pl. xvi, fig. 1).

In Borneo *Nipa* fruits were recorded from Eocene strata (Kraüsel, 1923, p. 77, pl. ii).

It will be noted that with the exception of Borneo, which lies within the present range of habitat of *Nipa*, all the above localities lie approximately along the margins of the ancient Nummulitic, or Tethys, Sea and its extensions.

V. 22042 Figured Pl. II, fig. 1. Small somewhat compressed fruit with the basal part well preserved. The nut is partly exposed by abrasion. *Reid & Chandler Coll.*, Warden, 1928.

V. 22043 Figured Pl. II, fig. 2. A small fruit enclosing a cast of the seed which is partly exposed by abrasion. This cast shows the impression of the characteristic ornamentation of the inner surface and of the cells of the testa. Outside it the fibres of the endocarp run transversely, but with occasional strong longitudinal fibres. Outside again, the fibrous mass of the mesocarp is visible.

V. 22044 Figured Pl. II, fig. 3. An abortive fruit.

V. 22045 Figured Pl. II, figs. 4, 6. An internal cast of a seed with a well-marked furrow on one side (extremely rare in *N. Burtini*, but usual in *N. fruticans*). It shows clearly the characteristic pattern of the inner surface of the testa. *W. Griffiths Coll.*, Sheppey.

V. 22046 Figured Pl. II, fig. 5. An internal cast of a seed surrounded by the apical part of the fruit.

The base of the "seed" (illustrated) shows the circular scar marking the aperture for germination and for the admission of the nutrient fibres.

V. 22047 Figured Bowerbank (1840, pl. i, fig. 5) as *Nipadites umbonatus*. A small abortive fruit.

V. 22048 Figured Bowerbank (1840, pl. iv, fig. 6) as *Nipadites Parkinsonis*. The basal part of an endocarp much worn showing the passage for germination and for the nutrient fibres.

V. 11021 Figured Bowerbank (1840, pl. v, fig. 1) as *Nipadites turgidus*. The internal cast of a large seed.

V. 15625 Figured Bowerbank (1840, pl. v, fig. 2) as *Nipadites turgidus*. The internal cast of a large seed with part of the pericarp still adhering.

V. 15624 Figured Rendle (1894, pl. vii, fig. B) as *Nipadites Parkinsonis*. A fruit of moderate size.

V. 22049 A small, probably immature fruit, much compressed, showing the transverse fibres of the endocarp exposed by the abrasion of a portion of the mesocarp.

V. 22050 Thirty-five specimens ; many are abortive or unripe, many are the upper halves of fruits only, many show casts of seeds and portions of the endocarp. *Reid & Chandler Coll.*, between Warden and Minster, 1928.

V. 22051 Twelve specimens, showing various stages of abrasion. One half-fruit shows the nut within. Some are immature or abortive. *Reid & Chandler Coll.*, Minister, 1929.

V. 22052 Small fruit which nevertheless encloses a well-developed though small seed.

V. 22053 Two small specimens ; one is broken in two pieces, the other is half a fruit only. One shows the remains of a seed, and the other a well-developed locule.

V. 22054–61 Eight fruits. One specimen (V. 22054) adhering to a fragment of a septarian nodule. *W. Griffiths Coll.*, Sheppey.

V. 22062–65 Four fruits. *Robertson Coll.*, Sheppey.

V. 22066–67 Two fruits. *G. A. Mantell Coll.*, 1839, Sheppey.

V. 9360, V. 11022–23 Three fruits.

V. 2860 A fruit. *S. H. Beckles Coll.*, 1891, Sheppey.

V. 22068 Cast of a seed still surrounded by the apex of the fruit.

V. 22069–70 Two apices of fruits. *W. Griffiths Coll.*, Sheppey.

V. 22071–72 Two specimens, one with the base somewhat broken, the other with only the apex preserved.

V. 22073–77 One small complete seed, somewhat bilaterally flattened ; one seed broken at the apex ; one seed with decayed testa still adhering ; one apex of a fruit with the remains of the seed-cast still inside ; one apex of a fruit (seed gone) broken in three pieces.

V. 22078 The lower three-quarters of an ill-developed fruit, now fractured. Important because it shows the basal passage for the embryo at germination, also the form of the basal part of the fruit which is rarely preserved. *Reid & Chandler Coll.*, Sheppey, 1928.

V. 22079 Internal cast of a seed. *W. Griffiths Coll.*, Sheppey.

V. 22080 Perfect internal cast of a seed showing the impression of the inner surface of the testa.

V. 12699 Internal cast of a bilaterally flattened seed, somewhat waterworn. Its surface still shows the impressions of the small cells which line the testa and of the ornamentation which characterizes its internal surface. *Collected and presented by W. H. Shrubsole*, Sheppey, 1897.

V. 22081 Imperfect cast of a seed.

V. 22082 Internal cast of a seed, fractured longitudinally, half only preserved.

V. 22083 Twelve specimens of young or abortive fruits, fragments of larger fruits, and three casts of small seeds.

V. 22084 Twenty-nine specimens of immature or abortive fruits, labelled "*Amomum* sp." by Ettingshausen.

V. 22085 Two small abortive fruits.

V. 22086 Thirty-five fruits, all immature or abortive.

V. 22087 A fruit from a septarian nodule. *A. G. Davis Coll.*, 1932, Hensbrook, Sheppey (foreshore).

V. 22088 A fruit from a septarian nodule. *A. G. Davis Coll.*, 1932. Two miles east of Minster, Sheppey (foreshore).

V. 22089 A fruit from a septarian nodule. *A. G. Davis Coll.*, 1932. The Potteries, New Malden, Surrey.

V. 12913–14, V. 12917 Three fruits from Shoeburyness, Essex. Others from the same collection have now been destroyed by decay. *Colld. by Quarter-Master-Sergeant J. J. Gurnet, presd. by Major (now Colonel) A. J. Peile*, 1913.

[**V. 7530** A fruit from Haverstock Hill. *Caleb Evans Coll.*, 1887. This specimen has now completely decayed.]

Unless stated to the contrary, the specimens catalogued above are from the Bowerbank Coll., Sheppey.

DICOTYLEDONES

Family JUGLANDACEAE

The family Juglandaceae is represented in the London Clay by five species of fruits, of which one only can definitely be referred to a living genus, *Platycarya* of Siebold and Zuccarini, which must now be named *Petrophiloides*. The remaining species show the nearest relationship with *Juglans*, but present characters which, in our judgment, debar them from inclusion in that genus. The discussion of these characters and of the relationship of the fossils will be found under the descriptions of the different species.

In describing the endocarps and seeds we have used the terms "primary" and "secondary" lobes (cf. Engler, 1894, iii, pt. 1, p. 21) because the former are present in every species belonging to the family, whereas the latter may be either more or less developed, or altogether absent. The primary lobes into which the base of the locule and seed are divided lie across the plane of dehiscence of the nut, parallel to one another and to a plane of symmetry at right angles to the plane of dehiscence. When the endocarp is intruded into the base of the locule so as to form a partial partition in the plane of dehiscence, the primary lobes are more or less subdivided at their bases, so that "secondary" lobes are formed, the four lobes thus formed lying at the corners of a square or quadrangle. Sometimes the intrusion is so slight that the primary lobes are emarginate rather than lobed; and sometimes there is no intrusion of the endocarp, so that the secondary lobing is absent. Secondary lobing appears sometimes to be of generic value, but sometimes only of specific value. Thus in the genus *Juglans*, whereas most species show secondary lobing, *J. cordiformis* shows almost none. Whether the absence of secondary lobing is a primitive character we do not know, but the facts that in *Petrophiloides Richardsonii* the secondary lobing is less marked than in the living species, and that in two of the fossil species allied to *Juglans* it is either absent or quite incipient, suggest very strongly that it may be; and that the seeds of primitive species of the Juglandaceae were on the whole simpler in form than those of some living members of the family. A similar simplicity of form is shown in the smoother contours of the fossil seeds as compared with the nodular contours of some of the living (most species of *Juglans*, *Pterocarya*, *Carya*).

The seeds of all Juglandaceae lie in the locules in such a manner that the two cotyledons are appressed against one another along the plane of dehiscence of the nut; that is, each valve of the nut contains a complete cotyledon. The primary lobes of the seed, which lie, be it remembered, at right angles to this plane, are therefore each formed by the halves of the two cotyledons; and the secondary lobes associated with any one primary lobe will belong to separate cotyledons.

Genus PETROPHILOIDES Bowerbank

1840. Foss. Fruits London Clay, p. 43.

Petrophiloides Richardsonii Bowerbank

PLATE II, figs. 7–20; text-fig. 1.

1840. *Petrophiloides Richardsonii* Bowerbank, p. 44, pl. ix, figs. 9–15; pl. x, figs. 5–8.
1840. *Petrophiloides cellularis* Bowerbank, p. 47, pl. ix, figs. 16, 17.
1840. *Petrophiloides cylindricus* Bowerbank, p. 48, pl. ix, figs. 18, 19.
1840. *Petrophiloides conoideus* Bowerbank, p. 48, pl. ix, fig. 20.
1840. *Petrophiloides ellipticus* Bowerbank, p. 49, pl. ix, fig. 21.
1840. *Petrophiloides imbricatus* Bowerbank, p. 50, pl. x, figs. 1–4.
1845. *Petrophiloides Richardsonii* Bowerbank (and other spp. as above): Unger, p. 229.
1850. *Petrophiloides* spp. (as Bowerbank 1840): Unger, p. 427.
1851. *Petrophiloides Richardsonii* Bowerbank: Ettingshausen, p. 715.
1851. *Petrophiloides imbricatus* Bowerbank: Ettingshausen, p. 715.
1854. *? Petrophiloides Richardsonii* Bowerbank: Ettingshausen, p. 33.
1860. *? Petrophiloides imbricatus* Bowerbank: Unger, p. 20, pl. vii, fig. 9.
1870. *Petrophiloides Richardsoni* Bowerbank: Schimper, p. 781.
1870. *Petrophiloides imbricatus* Bowerbank: Schimper, p. 781.
1871. *Petrophiloides Richardsoni* Bowerbank: Lyell, p. 240, fig. 206.
1879. *Sequoia Bowerbankii* Ettingshausen, p. 393.
1879. *Petrophiloides imbricatus* Bowerbank: Ettingshausen, p. 394.
1879. *Petrophiloides conoideus* Bowerbank: Ettingshausen, p. 394.
1884. *Alnus Richardsoni* (Bowerbank) Gardner, p. 417, pl. xxxi, figs. 1–12, 14, 15, 17, 18, 20–23.

DIAGNOSIS.—Inflorescence an ovoid stipulate strobil, with fruits borne in the axils of spirally arranged bracts. Fruits inferior, with persistent perianth, dorsi-ventrally compressed, one-loculed, one-seeded. Seed erect orthotropous, conforming to the shape of the locule, simple above, bilobed laterally below, and four-lobed at the extreme base; less deeply four-lobed than *P. strobilacea*. Length of strobil from about 11 to 33 mm. Length of locule-cast, 3 to 4 mm.

DESCRIPTION.—*Inflorescence:* A strobil, shortly stipitate, ovately cylindrical or ovoid, the fruits being borne in the axils of bracts arising at right angles to the thick axis, and are spirally arranged (Pl. II, figs. 7–10). The basal bracts are often infertile. Bracts coarsely striate on each surface, woody, thickened at the proximal end, flattened and imbricate at the distal end, convex on the lower surface, concave on the upper. The axis is formed by a core of coarse parenchyma (each cell being about 0·02 to 0·03 mm. in diameter) surrounded by a cylinder of fibres from which bundles pass into each bract and fruit (Pl. II, fig. 12); the bundles have spirally thickened fibres.

Bowerbank states that the strobils vary in size from sixteen lines long and ten and a-half lines broad to five and one-quarter lines long by four and a-half lines broad. In metric measure this gives: Length of largest, 33 mm.; breadth, 22 mm.; length of smallest, 11 mm.; breadth, 9 mm. The longest stalk recorded is " nearly half an inch " or about 10 or 11 mm. We have quoted Bowerbank's figures because he possessed a wider range of specimens than is now available.

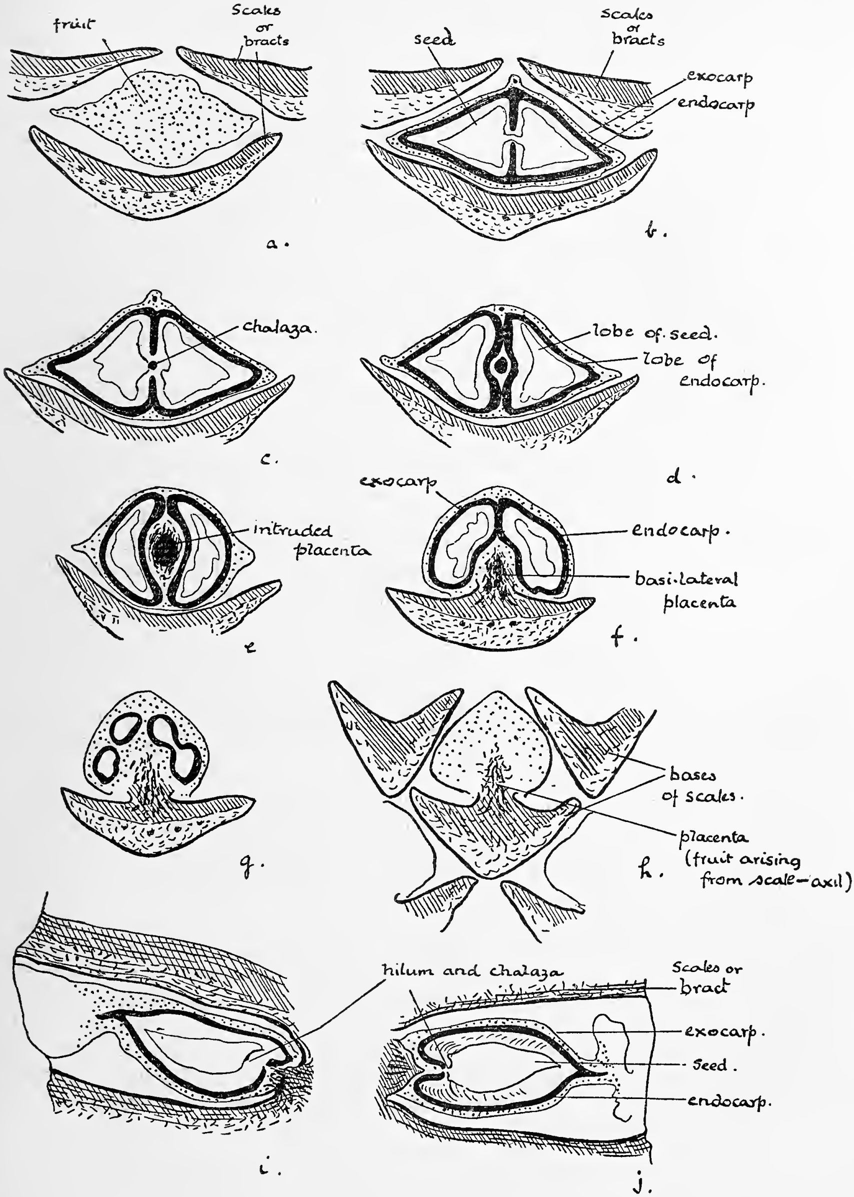
Fruit: Small, inferior, compressed dorsi-ventrally, flanged laterally, with a persistent perianth adherent below, free above, one-loculed, one-seeded (Pl. II, figs. 12–15 ; text-fig. 1 *i, j*). Surface striate with a few slender longitudinal ribs on each face, surface cells oblong, relatively smaller on the lower part, and larger on the upper part of the nut, where they are from 0·01 to 0·02 mm. long, and 0·01 mm. broad.

Endocarp: Ovate-mucronate, tapering into a long stylar beak, compressed dorsi-ventrally, sharply angled laterally, deeply emarginate at the base on the lower face, but not on the upper, the hollow on the lower face being filled by the receptacle (Pl. II, figs. 17–19 ; text-fig. 1 *f–j*). Below the cuneate apex, two deep median infolds of the endocarp project into the locule, one on the dorsal, the other on the ventral side, these unite towards the base to form a dorsi-ventral septum ; hence the locule, in its middle portion (between the extreme apex and the base) is laterally bilobed, and at the base has two distinct, deep, cup-shaped hollows (Pl. II, figs. 14, 17–19 ; text-fig. 1 *b–f*). But as each hollow is again divided by a slight basal infold of the wall at right angles to the other septum, the extreme base of the locule has four slight cup-shaped depressions, arranged at the corners of a trapezoid (Pl. II, fig. 16, where two of the four depressions are sectioned, also fig. 18 ; text-fig. 1 *g*). The walls of the endocarp are woody, formed of coarse parenchyma which in section has a columnar appearance. The locule lining shows large elongate, polygonal, or quadrilateral cells, aligned longitudinally ; they are about 0·05 mm. long and 0·016 mm. broad. Length of locule-cast, 3 to 4 mm. ; breadth, 2·3 to 2·7 mm.

Seed: Conforming in shape to that of the locule, triangular in outline at the apex both in the plane of dehiscence and at right angles to it, with two lateral primary lobes, slightly divided at the extreme base into four secondary lobes which are situated at the corners of a trapezoidal area ; erect, being seated astride the placenta and receptacle ; orthotropous. Sometimes, as can be seen in some sections, the space between the seed and locule wall is filled by large thin-walled cells which may measure 0·1×0·05 mm., but usually these have disappeared and the space is occupied by pyrites. (We have seen similar cells, similarly placed, in *Pterocarya rhoifolia* Sieb. & Zucc.)

REMARKS.—The bulk of the specimens of this fruit were given to Bowerbank by Mr. William Richardson, who collected some 300 " during the autumn and winter of 1837 on the beach near Swale Cliff, Herne Bay, where they had been washed out from a considerable mass of clay that had recently fallen from the face of the cliff." Bowerbank adds that the greater number of specimens had apparently undergone much compression and maceration prior to fossilization. A few specimens were also obtained from Mr. Hunt of Herne Bay. The originals of Bowerbank's pl. x, figs. 5–8, also from Herne Bay, which were the property of the Canterbury Museum,

FIG. 1 (p. 135).—*Petrophiloides Richardsonii.* *a–h,* Successive transverse sections across a fruit from apex to base (diagrammatic) : *a,* near the apex passing through the exocarp ; *b,* the middle of the fruit showing the bilobed endocarp and seed ; *c,* through the basal chalaza ; *d,* through the base where the endocarp is completely separated into two distinct lobes ; *e,* yet nearer the base, the endocarp has diminished in size and the placental column is larger ; *f,* nearer still to the base, the basi-lateral origin of the placenta and its relationship to the subtending scale can be seen ; *g,* at the extreme base of the fruit, the further subdivision of the primary lobes of the endocarp can be seen ; *h,* close to the axis, the outline of the exocarp can be traced, the endocarp has gone, but the origin of the placental mass is still clear. The scales near their point of origin are very small and narrow. *i–j.* Longitudinal sections through fruits showing exocarp, endocarp, placenta, and seed (diagrammatic) : *i,* dorsi-ventral section, showing the basi-lateral placenta ; *j,* section parallel to the dorsal and ventral surfaces showing the basal lobing of the endocarp.


fruit
Scales or bracts
a.
seed
Scales or bracts
exocarp
endocarp
b.
chalaza.
c.
lobe of. seed.
lobe of endocarp.
d.
intruded placenta
e
exocarp
endocarp.
basi-lateral placenta
f.
g.
bases of scales.
placenta (fruit arising from scale-axil)
h.
hilum and chalaza
i.
Scales or bract
exocarp.
Seed.
endocarp.
j.

have decayed. Subsequently more material was collected from the same locality by Gardner, and recently a few specimens were obtained by Mr. D. J. Jenkins.

A specimen described by Bowerbank as *Petrophiloides oviformis* (1840, p. 49, pl. x, figs. 10, 11) came from the beach below Minster Church, Sheppey. This clearly is not related to the Herne Bay specimens. For a discussion of its affinities, see p. 205.

On p. 95, under the name *Sequoia* (?) *Shrubsolei* Gardner, we have discussed the possible relationship to *Petrophiloides* of a cone or strobil sent to Gardner by W. H. Shrubsole, from Sheerness.

A single strobil found by ourselves in 1929 at Minster (Pl. II, fig. 20) is important because it is the only one definitely known from any locality other than Herne Bay. It is sub-globular in form and distorted obliquely so as to appear rather shorter than in life. Except that the exterior is much worn and partially obscured by structureless pyrites, the specimen is beautifully preserved; the grey pyrites, in which the central axis of the cone and the bracts are largely preserved, contrasts with and clearly defines the dark carbonaceous matter of the endocarp and perianth. The endocarp wall is peculiarly well preserved and shows a marked thickening towards the apex. The number of fruits in the length of the strobil is small, but some of the Herne Bay strobils show an equally small number of fruits.

Although many specimens of *Petrophiloides*, including the majority of Bowerbank's figured specimens and some of Gardner's, have vanished, and others have deteriorated since they were collected, many remain in a good state of preservation. It has been possible, therefore, not only to study the external appearance, but to examine the internal structure of some of them in great detail by means of natural fractures, by dissections of strobils and fruits, and by serial sections. Such studies show that the interstices between the carbonaceous imbricate bracts and the fruits have been filled by pyrites (Pl. II, figs. 12, 14, 15) as was originally suggested by Gardner (1884, p. 417); so that the fossil cone is formed of a series of alternating areas of hard pyrites and soft carbonaceous matter. Owing to this mode of preservation the hard and soft material has been differently abraded; so that great differences in appearance may result, which may be correlated with the degree of abrasion that has taken place.

On such differences of appearance Bowerbank based his division of the genus into six species (the seventh species, *P. oviformis*, as already stated, does not belong to the genus), namely, *P. Richardsonii*, *P. cellularis*, *P. cylindricus*, *P. conoideus*, *P. ellipticus*, *P. imbricatus*. In our opinion, all these are but varying forms of a single species, dependent upon the degree of abrasion.

The most perfect form appears to be represented by a specimen which Bowerbank figured as *P. imbricatus* (1840, p. 50, pl. x, figs. 1–4). It has now disappeared. The figures and description show that it possessed non-confluent imbricate bracts. Bowerbank was puzzled by this specimen and regarded it as anomalous. Nevertheless, he states that the seeds, except that they "are broader in proportion to their length than those of *P. Richardsonii* . . . in other respects . . . very much resemble them." The broader proportion of the "seeds" is probably accidental or due to the compression of the strobil, and we have no hesitation in suggesting that

P. imbricatus was merely a specimen in which the distal imbricate ends of the bracts were partially preserved. Usually these ends are abraded, and the evidence for imbrication is then destroyed, only the thick basal parts remaining, embedded in pyrites.

For the sake of clearness we summarize below some of the most marked appearances due to successive stages of abrasion :—

(1) When the imbricate distal ends of the bracts are partially preserved, the effect is that seen in *P. imbricatus*, the bracts concealing the pyrites infillings.

(2) When the strobils have been so abraded that the distal ends of the bracts are worn away, the surface shows a series of sub-quadrilateral pyrites areas, more or less confluent at their angles, alternating with the worn-down remains of the real bracts (Pl. II, figs. 7, 8). In such specimens the pyrites-filled interspaces may present a false appearance of peltate cone-scales such as are seen in *Sequoia*. The appearance is enhanced when, as often happens, the true carbonaceous bracts have decayed leaving their empty crescentic sockets between the pyrites areas (Pl. II, fig. 10). Bowerbank interpreted such specimens as showing a series of dehisced scales (the pyrites areas) with semicircular mouths (the spaces formerly occupied by the bracts). In actual fact the fruits are still embedded in the pyrites, one in each pyrites area ; hence they are not visible except when much abrasion has caused their apices to protrude, giving the appearance of umbones (cf. Bowerbank, 1840, p. 49).

(3) A further stage of abrasion has been observed in a few cases where the pyrites has broken away as a cap so that the embedded fruits are exposed (Pl. II, fig. 9). In such specimens the proximal ends of the bracts may be preserved beneath the fruits, in a more or less pyritized condition. Sometimes the fruits have dropped out, but the bases of the pyritized bracts remain, closely invested by layers of hard thin pyrites, confluent around adjacent bracts. When this has happened the strobil shows a series of gaping pockets with confluent walls which form a lattice-work (Pl. II, fig. 11).

(4) When completely stripped of bracts, fruits, and pyrites fillings, the surface of the remaining obovoid axis displays a series of lozenge-shaped scars each with a median umbo (cf. Bowerbank, 1840, p. 47, pl. ix, figs. 16, 17).

Before passing to the consideration of its affinities we may state that the fruit is seen to be inferior in longitudinal sections, which show the free ends of the persistent perianth arising from its apex. Its firm and rigid character is shown by the way in which it always stands out stiffly. Had it not been more or less rigid, it must have been crushed and crumpled (Pl. II, fig. 13 ; text-fig. 1 *i*, *j*).

The " seed " described by Bowerbank and Gardner is actually the cast of the locule (Pl. II, figs. 17–19) ; it readily falls free, leaving the carpel walls adhering to the pyrites in which they are embedded, and bears on its surface the imprint of the cells forming the locule-lining. Owing to the marked cohesion between the fruit walls and the surrounding pyrites, the surface of a fractured strobil normally displays the locule-casts and not the external surface of the fruits (cf. Bowerbank, pl. ix, fig. 13). The true seed lies within the locule-cast, and shows on its surface the delicate polygonal cells of the testa.

Affinities.—The inferior fruit seated astride the placenta, with its single erect seed, bilobed laterally and slightly four-lobed at the base, place this much discussed fruit beyond doubt in the family Juglandaceae. A similar inflorescence with comparable fruits, seeds, and cell-structure occurs in *Platycarya* Sieb. & Zucc. The only living species, *P. strobilacea* Sieb. & Zucc., is a tree native to China and Japan. Its seeds and endocarps are more deeply four-lobed at the base than those of the fossil. The bracts of its strobils are long, narrow, and acutely pointed, whereas those of the fossil, so far as they are known, are broader and shorter, as shown by Bowerbank's figures (1840, pl. x, figs. 1–4). Otherwise the inflorescence, fruits, and seeds are very similar. *Petrophiloides Richardsonii* and *Platycarya strobilacea* are therefore certainly congeneric, though specifically distinct. The former generic name, however, has priority, for the genus was actually discovered in the fossil state before it was known living, Bowerbank's description having been published in 1840, whilst Siebold and Zuccarini's was not published until 1843 (*Abh. Akad. Muenchen*, III, 3, p. 741). The name *Platycarya* therefore becomes a synonym of *Petrophiloides*, and the living species must be renamed *Petrophiloides strobilacea* (Sieb. & Zucc.).

The fossil fruits of *P. Richardsonii* were described by Bowerbank as closely allied to *Petrophila*, a genus belonging to the family Proteaceae. The cones of *Petrophila* have much the same size and form as those of *P. Richardsonii*, but Bowerbank's interpretation of the form of the scales as "confluent rarely separate" and forming "well-defined cells, each containing a single seed" was erroneous. And he himself recognized that the "seed" did not agree with that of *Petrophila*, being bilobed and having no "comose appendage."

In 1854 (p. 33) Ettingshausen recorded *P. Richardsonii* from Monte Promina; but his determination cannot be considered as established since his description is inadequate and he gives no illustration. Yet he wisely united five of Bowerbank's seven species under the name *P. Richardsonii*, retaining as distinct species *P. imbricatus* and *P. oviformis* (1851, p. 715; 1854, p. 33).

In 1860 (p. 20) Unger described as *P. imbricatus* Bowerbank a specimen from Sotzka. But the cone figured might equally well be an alder, or any other cone of similar appearance. There is no detailed description, so that, again, the evidence cannot be considered as adequate to support the determination.

In 1870 Schimper (p. 781) listed two species only, *P. Richardsonii* and *P. imbricatus*.

In 1871 Lyell reproduced some of Bowerbank's specimens and stated (p. 240) that he had submitted the fossils to Carruthers, who confirmed their relationship to the proteaceous genera *Petrophila* and *Isopogon*.

In 1879 Ettingshausen (pp. 393, 394) listed, but without figures or descriptions, *Sequoia Bowerbankii* Ett., in which he included *Petrophiloides Richardsonii*, *P. cylindricus*, *P. cellularis*, and *P. ellipticus*; he retained *Petrophiloides imbricatus* and *P. conoideus* as distinct species referable to the Proteaceae. In the same paper he stated that "some of the cones referred by Bowerbank to *Petrophiloides* belong to *Sequoia*." The only jar labelled "*Sequoia Bowerbankii* Ett." by him contained specimens of *P. Richardsonii* Bowerbank only.

In 1879 (p. 223) Gardner recorded a specimen from the Boscombe sands, Hampshire, which he stated resembled *Petrophiloides*. But no figures or descriptions were given. Later, in 1884 (p. 417), he described and figured a number of specimens of *P. Richardsonii* from the original locality in the London Clay under the name *Alnus Richardsoni*. The credit belongs to him of interpreting the " apparent peltate scales " as pyrites-infillings between the bracts, although his interpretation of the form of the bract was incorrect. He was also in error in stating that " the seed exactly resembles those of *Alnus*." Its very marked lobing should have shown him otherwise.

V. 22090 Figured Pl. II, fig. 7. A small strobil showing the stalk, and the bracts immersed in a mass of structureless pyrites.

V. 22091 Figured Pl. II, fig. 8. A larger strobil showing the mud infilling even more clearly. Labelled " *Petrophiloides imbricatus* Bow." by Ettingshausen.

V. 22092 Figured Pl. II, fig. 10. Part of a strobil in which the bracts have decayed and broken away leaving the mud infillings, which have the appearance of peltate scales, between them (cf. Bowerbank, 1840, pl. ix, fig. 12).

V. 22093 Figured Pl. II, fig. 9. A strobil; the mud areas have in places fallen away, carrying with them the apices of the fruits, thereby exposing the locule-casts. In a few cases the locule-casts have also fallen out, leaving empty sockets.

V. 22094 Figured Pl. II, fig. 11. A much worn strobil from which the fruits have fallen. Their empty sockets are delimited by the structureless pyrites in which they and the bracts were buried.

V. 22095 Figured Pl. II, fig. 12. A radial longitudinal section of a strobil showing the axis, the bracts arising from it, and the fruits arising in the axils of the bracts. The fruits are all cut longitudinally, parallel to the plane of symmetry, but the section passes along a different plane in each, exhibiting an apparent variety of form. A seed can usually be seen in each fruit; in some cases it is much shrivelled and has shrunk from the endocarp. In a few fruits the interspace between seed and locule is filled with coarse thin-walled parenchyma.

V. 22096 Figured Pl. II, fig. 13. A strobil transversely sectioned showing fruits and scales. The fruits are cut longitudinally at right angles to the plane of symmetry. One fruit shows clearly the coarse thin-walled parenchyma which is sometimes present between the testa and the locule wall.

V. 22097 Figured Pl. II, figs. 14–16. A strobil in which a series of longitudinal tangential sections were made by grinding down the specimen. The fruits were thereby cut transversely at successively greater distances from their apices, the different stages being photographed as they were exposed. The earlier sections (now destroyed) passed through the bilobed region of the fruits, the later ones passed through the separated lobes, basal chalazas, or the basi-ventral hilums, and through the placentas lying between the two lobes of each fruit. The later sections (the last still extant) showed the evidence for secondary lobes at the extreme base of each fruit.

V. 22098 Figured Pl. II, fig. 17. A large locule-cast figured to show the upper surface.

V. 22099 Figured Pl. II, fig. 18. A small locule-cast figured to show the lower surface and basi-ventral hollow for the placenta. The subdivision into four lobes can be seen at the lower end of the cast.

V. 22100 Figured Pl. II, fig. 19. A small locule-cast showing the basal end and basi-ventral hollow very clearly.

V. 22101 Figured Pl. II, fig. 20. A small strobil, fractured longitudinally to show the structure, *Reid & Chandler Coll.*, Minster, 1929.

V. 22102 Figured by Bowerbank (1840, pl. ix, fig. 18) as *Petrophiloides cellularis*. A denuded strobil-axis. A loose label, doubtless belonging to this specimen, was inscribed " *Petrophylloides cellularis* Herne Bay, Bowerbank Collection (axis deprived of scales of *P. Richardsoni*), Figd. Bowb., pl. ix, figs. 16, 17." One specimen only remained in the jar, the original of fig. 17 having disappeared.

V. 22103 Figured by Bowerbank (1840, pl. ix, fig. 19) as *Petrophiloides cylindricus*. A denuded axis of a strobil. A loose label, which must belong to this specimen, was inscribed " *Petrophylloides* *cylindricus* Herne Bay, Bowerbank Collection. Immature cone of *P. Richardsoni*, pl. ix, fig. 19."

V. 22104 Figured by Bowerbank (1840, pl. ix, fig. 20) as *Petrophiloides conoideus.* A denuded strobil axis.

V. 22105 Figured by Bowerbank (1840, pl. ix, fig. 21) as *Petrophiloides ellipticus.* A strobil-axis stripped of its bracts but still retaining some of its fruits. A loose label, which must belong to this specimen, bore the inscription "*Petrophylloides ellipticus* Herne Bay, Bowerbank Collection. *P. Richardsoni* (immature), pl. ix, fig. 21."

V. 15199 Figured by Gardner (1884, pl. xxxi, fig. 2). Strobil, now almost decayed.

V. 15200 Figured by Gardner (1884, pl. xxxi, fig. 5). Strobil, now almost decayed. *J. S. Gardner Coll.*, 1884.

V. 15201 Figured by Gardner (1884, pl. xxxi, fig. 6). Strobil, decayed. *J. S. Gardner Coll.*, 1884.

V. 15202 Figured by Gardner (1884, pl. xxi, fig. 9). Strobil. *J. S. Gardner Coll.*, 1884.

V. 15203 Figured by Gardner (1884, pl. xxxi, fig. 21). Strobil, now decayed.

V. 662 Six fragments of cones. A label associated with the specimens, inscribed "*Alnus Richardsoni* Gard. V. 662. Bowerbank Collection. Figd. Bow. Hist. Fossil Fruits & Seeds. 1840, pl. ix, figs. 14, 17, 21."

The original of fig. 21 is, as stated above, specimen V. 22105; the originals of figs. 14 and 17 cannot be recognized in the fragments numbered V. 662, but these specimens are so decayed and broken that they may be types which are no longer recognizable.

V. 22106 Several good strobils. Two are intact, one is fractured longitudinally, and one transversely. The fractured cones show casts of several fruits *in situ*.

V. 22107 A somewhat crushed and flattened strobil.

V. 22108 A strobil sectioned transversely to show the mode of origin of the scales.

V. 22109 A strobil fractured longitudinally, to show the fruits and the cell-structure of the axis.

V. 22110 A denuded axis.

V. 22111 A fragment of an axis, from a jar with the original of Bowerbank's pl. ix, fig. 19 (cf. V. 22103). So far as can be discovered in its present broken condition, it does not represent any of Bowerbank's other figured specimens.

V. 22112 A detached fruit with part of the exocarp.

V. 22113 A fruit fractured longitudinally to show the locule.

V. 22114 A detached fruit fractured longitudinally. Coarse, thin-walled parenchyma occupies the interspaces between locule wall and testa.

V. 22115 Two detached fruits; one is fractured longitudinally and shows a piece of the internal cast of the seed within the locule.

V. 22116 Numerous strobils.

V. 22117 Numerous detached scales and fruits, partially embedded in pyrites.

V. 660 A strobil. *J. S. Gardner Coll.*, 1884.

The majority of the specimens were originally in a jar labelled by Ettingshausen "*Sequoia Bowerbankii* Ett."

All but V. 22101 are from Herne Bay.

All but V. 22101, V. 15200–02, *and* V. 660 *are from the Bowerbank Coll.*, Sheppey.

Genus JUGLANDICARYA nov.

Diagnosis.—Fruits which, although clearly referable to the Juglandaceae, are of doubtful generic relationship both to living genera and to one another.

Juglandicarya Lubbocki n. sp.

Plate III, figs. 1–4.

Diagnosis.—Endocarp globular, smooth, dehiscing into equal valves, one-loculed, one-seeded; walls thick without cavities. Seed erect, orthotropous, conforming to the shape of the locule, simple above, deeply four-lobed below, contours smooth. Length about 8 mm. Length of primary lobes one-half to three-fifths that of seed. Length of secondary lobes about two-fifths that of the seed.

Holotype.—V. 22118.

Description.—*Endocarp:* Small, globular, smooth as preserved, very thick-walled in proportion to its size, dehiscing into two symmetrical valves along a lateral suture; a strand of fibres runs along the margins of the suture. One-loculed, one-seeded; locule simple at the apex, but subdivided below, by incomplete septa, into four compartments. A fibrous axis runs within the septa from the base of the endocarp to the placenta, which is median where the free edges of the septa intersect. Endocarp wall without any visible cavities, formed throughout of coarse, close, woody parenchyma; locule-lining coarsely granular. Length of endocarp, 8 mm.; breadth, 8·5 mm.

Seed: Erect, orthotropous, conforming in shape to the locule; apex compressed, broadly triangular in the plane of dehiscence of the endocarp and rather narrowly triangular at right angles to this plane (Pl. III, figs. 3, 4); expanded below, deeply four-lobed owing to the subdivision of the two primary lobes, the bases of the four lobes being closely adjacent; micropyle apical; hilum basal, sunk between the lobes. Surface of seed smooth without corrugations or nodulations; testa pitted externally and traversed by a few conspicuous branching longitudinal fibres. Length of locule (virtually of seed), 6·5 mm.; diameter in plane of dehiscence, 6 mm.; diameter at right angles to plane of dehiscence, 4·5 mm.; length of primary lobes, about half or three-fifths that of the seed; length of secondary lobes, about two-fifths that of the seed. Length of seed in a second specimen, 7 mm.; diameter in both directions, 5·25 mm.; length of primary lobes about three-fifths that of the seed; of secondary lobes about two-fifths that of the seed.

Remarks.—Two specimens, of which one was perfect; also a doubtful specimen. The best preserved of these, a little globular bisymmetric endocarp, showed no distinctive characters so that it was at first impossible to determine its affinities. It was, therefore, fractured, whereupon the seed appeared. It was characteristic in form of the family Juglandaceae. The second specimen has lost the greater part of its endocarp, so that its relationship is at once apparent. It has also undergone slight distortion, so that the length of the secondary lobes appears slightly different on the two sides.

The two specimens differ somewhat in proportions. In one the apical end of the seed is more compressed than in the other. Further, a corresponding difference occurs in the position of the basal lobes. In the compressed seed these occupy the corners of a rectangle, having its major axis in the plane of dehiscence. In the other they lie at the corners of a square. But inasmuch as in all essentials, such as the general form, character of the lobes, and smoothness of contour, the two specimens differ from one another no more than two specimens of a living species may differ, we consider that they must be placed in a single species.

Affinities.—While we have no hesitation in assigning these fossils to the family Juglandaceae, their relationship to living genera is difficult to determine. The external form of the nut is inconclusive, but the character of the locule and seed, and the structure of the endocarp give valuable evidence. As regards the form of the locule and seed, the fossils undoubtedly more nearly resemble *Juglans* Linn.

than any other living genus. Seeds with smooth contours occur in *J. mandschurica* Maxim., *J. insularis* Griseb., *J. nigra* Schwarz, and probably also in other species. Nevertheless, there are three distinctions which appear to us to prohibit the inclusion of these fossils in the genus *Juglans:* The endocarp is smoothly globular; it has no conspicuous cavities, if any at all, in its wall; it is extremely small, from one-third to one-quarter the size of any living species. In view of these differences, and especially of the absence of cavities, which in *Juglans* are very large and conspicuous, we do not include the fossil in that genus. In respect of the absence of cavities, it more nearly resembles the genus *Carya* Nutt., in which they are so small that after fossilization they might be overlooked. The lobing of the seed, however, and its general form are unlike those of *Carya*, and the size of the endocarp, although nearer to *Carya* than to *Juglans*, is nevertheless too small for that genus. We have therefore placed the fossil in the form-genus *Juglandicarya.*

In his work "On Seedlings" Lubbock suggested that in the ancestral forms of *Juglans* the nuts were smaller than in the living species (1892, vol. ii, p. 512). This suggestion receives confirmation from the small size of the London Clay endocarps. We have therefore named this small species *Juglandicarya Lubbocki.*

V. 22118 Holotype, figured Pl. III, figs. 1–4. An endocarp, with cast of locule and seed.
V. 22119 A cast of locule and seed from which the endocarp has been largely abraded.
Both the above are from the Bowerbank Coll., Sheppey.
V. 22120 A poorly preserved endocarp which split along the plane of dehiscence and subsequently broke into several more pieces. The primary lobes appear to be subdivided into well-marked secondary lobes as in *J. Lubbocki*, to which species the specimen should probably be referred. *Reid & Chandler Coll.*, Minster, 1929.

Juglandicarya cantia n. sp.

Plate III, figs. 5–7.

Diagnosis.—Endocarp globular, smooth, and without external nodulations, dehiscing into equal valves, one-loculed, one-seeded; walls thick, without cavities. Seed erect, orthotropous, conforming to the shape of the locule, simple above, two-lobed below, each lobe being slightly emarginate at the base. Diameter of endocarp about 12 mm.

Holotype.—V. 22121.

Description.—*Endocarp:* Globular, smooth, and without external nodulations, dehiscing into two equal symmetrical valves, one-loculed, one-seeded; locule simple at the apex but subdivided at the base into two deep compartments by a septum transverse to the plane of dehiscence (Pl. III, fig. 5). Placenta median at the free edge of the septum, fibres from the attachment of the nut to the placenta running in the thickness of the septum. Endocarp wall relatively thick, formed throughout of coarse parenchyma, without any visible cavities; lining of locule evenly pitted. Diameter of endocarp, 12 mm.; maximum thickness of wall, 1·5 mm.

Seed: Erect, orthotropous, seated astride the placenta and septum; conforming in shape to the locule, hence entire above, deeply bilobed and saddle-shaped below. Apex broadly triangular in the plane of dehiscence of the nut, compressed at right angles to this plane ; primary lobes closely approximated below, expanded at right angles to the plane of dehiscence, compressed in the direction of that plane, not bifid to form secondary lobes (Pl. III, fig. 7) as in *J. Lubbocki*, but slightly emarginate at the base ; each lobe is concavo-convex, the concave sides being towards the septum ; surface slightly undulating but not nodular, with a few branching longitudinal fibres ; cells of testa polygonal. Length of locule (virtually of seed), 10 mm. ; breadth in plane of dehiscence, 9 mm. ; breadth of lobes, 7 mm. ; length of second specimen, 9 mm. ; breadth in plane of dehiscence, 8·5 mm. ; breadth of lobes, 7 mm.

REMARKS.—Two specimens. The larger of these is a globular, featureless endocarp. As it was impossible to tell from the exterior what kind of fruit it represented, we fractured it, revealing the well-characterized locule and seed. The second specimen is an internal cast of the locule with adherent remains of the endocarp, so broken and worn in parts as to expose the seed.

AFFINITIES.—The form of the locule and seed, and the placentation, place these nuts in the family Juglandaceae. In their shape and in the relative position of the lobes the seeds most nearly approach the genus *Juglans ;* also the character of the secondary lobing and of the smooth contours can be approached in *Juglans*, although they are more characteristic of some other genera ; thus in *J. cordiformis* the secondary lobes are almost absent, the primary lobes being merely emarginate, and the contours are less nodular than in most species, although more nodular than in the fossil. We do not think that the resemblance in the general form of the seeds, which is really the only feature at all distinctive of *Juglans*, justifies inclusion of the fossil in that genus ; more especially in view of its very much smaller size. We have referred the fossil to the form-genus *Juglandicarya*, giving the specific name *cantia*.

V. 22121 Holotype, figured Pl. III, figs. 5, 6. An endocarp fractured to expose the internal cast of the locule, and the seed.

V. 22122 Figured Pl. III, fig. 7. An internal cast of locule and seed.
Both from the Bowerbank Coll., Sheppey.

Juglandicarya depressa n. sp.

PLATE III, figs. 8–13.

1879. *? Musa eocenica* Ettingshausen, p. 393.

DIAGNOSIS.—Endocarp roundly quadrangular or circular, compressed dorsiventrally, fibrous externally, one-loculed, one-seeded ; walls thick. Seed erect, orthotropous, conforming to the shape of the locule, simple above, deeply two-lobed below ; lobes closely approximated, flat or concavo-convex, sometimes emarginate at the base.

HOLOTYPE.—V. 22123.

DESCRIPTION.—*Endocarp :* Roundly quadrangular or circular, more or less compressed dorsiventrally, dehiscing into two valves along a plane which usually passes through two of the angles of the quadrilateral fruit, the other two angles being approximately intermediate in position. External surface (as preserved) fibrous, the fibres diverging from the base and apex to the equator of the nut. One-loculed; one-seeded; the locule being simple above and deeply subdivided below by an imperfect septum which lies transversely to the plane of dehiscence. Placenta median on the free edge of the septum. Endocarp wall very thick in proportion to the size of the fruit, formed of coarse parenchyma with a few strands of fibres passing from base to apex; occasionally the fibres branch and anastomose, as shown by a section at right angles to the plane of dehiscence. Length of endocarp (always abraded) in five specimens, 5, 6, 5·5, 4, and 5 mm. respectively; greatest breadth in the same specimens, 10, 12, 10·5, 7·5, and 10 mm. respectively; least breadth, 8, 10, 8, 6·5, and 7·5 mm. respectively.

Seed: Small in proportion to the fruit; erect, orthotropous, seated astride the placenta, conforming in shape to the locule, hence simple above, and deeply bilobed (saddle-shaped) below (cf. Pl. III, fig. 13). Apex broadly triangular in the plane of dehiscence of the nut, compressed at right angles to this plane; basal lobes closely approximated, flat, or concavo-convex with the concave sides towards the septum, sometimes slightly emarginate at the base, but often entire. Length of locule (virtually of seed), 3·5 mm.; breadth of lobes at right angles to plane of dehiscence, 3 mm.; thickness of lobes in plane of dehiscence, 1 mm.; distance between lobes in an isolated cast freed of endocarp, 1·5 mm.

REMARKS.—About twenty unbroken, but worn, specimens and several fragments. In almost every case the base and apex are so abraded as to expose the locule-cast (Pl. III, figs. 10, 11). The surface is always much worn so that the true exterior is never seen, and the cell-structure is obscured. One specimen showed external fibres, another showed the wall in section, and a locule-cast freed from the carpel showed the form of the locule and seed (Pl. III, fig. 13).

AFFINITIES.—The relationship of the specimens to Juglandaceae is clearly evidenced by the form of the locule and seed. The flattened fruit and the external fibres directed to the equator both from the base and apex, suggest that in its original condition the fruit may have been winged and somewhat similar in form to *Pterocarya*. If so no trace of the wing remains, as indeed is inevitable after such vicissitudes as the London Clay fossils have undergone during, and after, fossilization. Although the seed approximates in size to *Pterocarya*, the endocarp wall is much thicker and the fruit is correspondingly larger than in that genus. Also the basal lobes differ from those of *Pterocarya* in their much greater parallelism and their closer proximity, and in the absence of clear secondary lobing (Pl. III, fig. 11).

In *Juglans* the lobes of the seed are closely approximated at the base and are nearly parallel. Sometimes, too, the secondary lobing is absent or incipient only. But in its small size and compressed form the fossil differs from any species of *Juglans*. We have named it *Juglandicarya depressa*. A worn nut of this species, now completely decayed, was labelled "*Musa* . . ." by Ettingshausen. It was probably the original of his undescribed species, "*Musa eocenica*."

V. 22123 Holotype, figured Pl. III, figs. 8, 9. A relatively unabraded nut.
V. 22124 Figured Pl. III, fig. 10. An endocarp, abraded so that the apex of the locule-cast is exposed.
V. 22125 Figured Pl. III, fig. 11. An endocarp, abraded so that the base of the locule-cast is exposed.

V. 22126 Figured Pl. III, fig. 12. An endocarp in which the plane of dehiscence is clearly defined by the infiltration of pyrites along the fissure.
V. 22127 Figured Pl. III, fig. 13. A locule-cast (virtually a seed) with remains of carpel wall adhering.
V. 22128 Nine specimens, all more or less abraded.
All the above are from the Bowerbank Coll., Sheppey.
V. 22129 Nine specimens, also several fragments. *Reid & Chandler Coll.*, between Eastchurch and Minster, 1928.
V. 22130 Forty nuts. *Reid & Chandler Coll.*, Minster, 1929.

Juglandicarya crassa (Bowerbank)

1840. *Cupressinites crassus* Bowerbank, p. 59, pl. x, fig. 9.
1845. *Cupressites crassus* (Bowerbank) Unger, p. 192.
1847. *Hybothya crassa* (Bowerbank) Endlicher, p. 11.
1850. *Hybothya crassa* (Bowerbank): Unger, p. 346.
1879. *Hybothya crassa* (Bowerbank): Ettingshausen, p. 392.
1883. *Callitris curta* (Bowerbank) Gardner, p. 21, pl. ix, fig. 12.
1919. *Callitrites curta* (Bowerbank): Seward (pars), p. 340, fig. 761 B, C.

On p. 59 (1840) Bowerbank describes, and on pl. x (fig. 9) figures, a specimen which he names *Cupressinites crassus*. He states that it is only " half a cupule," and regards it as representing two segments [valves] of a cone similar to the cones of *Thuja*. He states that each valve is triangular, and Sowerby's figures show this to have been the case. They also show that the two sides which Bowerbank regarded as the internal faces met at an angle whilst the external face (curved longitudinally) was faceted against them. Bowerbank also states that the two internal faces were seed-bearing, one seed on each face. Sowerby's figures also show that a pair of the so-called seed-bearing faces (one face belonging to each segment) are turned towards the plane of fracture, so that a similar pair of seed-bearing faces in the missing half of the specimen must have faced them. Now in *Thuja* the valves (or segments) are triangular in cross-section, but the triangle is formed by a flat (or slightly hollowed) seed-bearing face turned to the axis of the fruit, and an angled external face, or a convex external face. Consequently there are fundamental distinctions between the fossil segments and those of *Thuja*, such that, by no possibility, could a section be taken between two pairs of segments in the cones of *Thuja* which would result in a pair of seed-bearing faces being turned to the plane of section.

It seems certain, therefore, that Bowerbank's specimen, now disappeared, did not represent any species related to the Cupressineae.

His figures seem rather to represent the internal cast of a valve of an endocarp belonging to the Juglandaceae, represented in an inverted position. If such an interpretation be correct, the specimen must have been equivalent in form to half a seed. The " stalk " described by Bowerbank would, on this interpretation, have corresponded with the radicle, and the " segments of the cupula " with one of the bilobed cotyledons. In his diagnosis he describes the *cupula* as " four-cleft; divisions fleshy, nearly triangular and terminating in a point." On the fractured face of the figure, which on our interpretation represents the face of the locule-cast fractured along the plane between the cotyledons, Sowerby shows two oval, slightly sunk areas (Bowerbank's seeds). We regard these as representing the two lobes of the shrunken seed itself, surrounded by the locule-cast. We have no doubt but that this is the true interpretation of the specimen and refer the fossil to the form genus *Juglandicarya,* but the specimen having disappeared, it is impossible to carry the determination further. The dimensions based on Bowerbank's figures are: length, 14 mm.; greatest breadth across the cotyledons, 19 mm. We believe that these figures may be accepted as accurate, because in other cases where we have had opportunity to check Sowerby's drawings by the actual specimens they have been found to be scrupulously accurate. Hence the specimen must have been distinguished from any other species which we have referred to the form-genus *Juglandicarya* by its greater size.

In 1883 the fossil was refigured by Gardner (pl. ix, fig. 12) as *Callitris curta;* but his figures differ distinctly from those of Bowerbank, and show a greater similarity to a cupressineous cone. In view of the much greater accuracy of Sowerby's than of Gardner's drawings, to whose defects in this respect we have had occasion in a previous work to draw attention (Reid & Chandler, 1926, p. 48), we regard Bowerbank's illustration as probably the more reliable of the two.

In 1919 (fig. 761 B, C) Professor Seward refigured the specimen. The figures are stated to have been drawn from the specimen described by Gardner, natural size. They differ considerably from Sowerby's original drawings of the specimen and show two segments divided to the base as in Gardner's figure, not in Sowerby's.

Family URTICACEAE ?

Genus URTICICARPUM nov.

Diagnosis.—Fruit a discoid, ovate, slightly asymmetric achene; exocarp papery; endocarp thick, surface pitted, and undulate, the undulations radiating from the centre of each side and terminating at an obscure sub-marginal depression.

Urticicarpum scutellum n. sp.

Plate III, fig. 14.

Diagnosis.—That of the genus.

Holotype.—V. 22133.

Description.—*Fruit:* An achene, discoid, ovate, but asymmetric, the style being sub-apical, the base slightly truncate. Exocarp very thin and papery. Endocarp thick; the surface, which is finely and evenly punctate, is also thrown into rather obscure low undulations which radiate from the centre and end at a shallow sub-marginal depression. The presence of this depression gives rise to a marginal rim not otherwise defined. Length of fruit, 5·6 mm.; breadth, 5 mm.; thickness, 2 mm.; diameter of cells on endocarp about 0·015 to 0·02 mm.

Affinities.—One specimen found by ourselves at Minster in 1929. Achenes (or samaras ?) of this type occur, so far as we are aware, in very few families. We know them in the section Anemoneae of the Ranunculaceae, and in the Urticaceae. The achenes of the Rosaceae are not only different in form but the cells of their endocarps are different also. Hence alliance with the Rosaceae is excluded, and the Ranunculaceae and Urticaceae alone remain for consideration. In both of these families genera with flattened, ovate, asymmetric endocarps occur. In the former family the achenes which bear the closest resemblance are those of *Ranunculus* Linn. They are usually flat and sub-ovate, and frequently have pitted surfaces and marginal rims, also the style is usually sub-apical. But even the largest are much smaller than the fossil, the rim is more marked, and the pitting much coarser. Frequently, also, the endocarps are narrowed at the base or sub-stipitate.

The resemblance to the Urticaceae is much closer. Species in many genera have endocarps which are not dissimilar in size and shape, for example, in *Pteroceltis* Maxim., *Girronniera* Gaudich, *Cudrania* Tréc. The pitting in the family is finer and closer, more as in the fossil, and the rim is less marked than in *Ranunculus*; the asymmetry is of a similar order to that seen in the fossil, the style being sub-apical. In shape and size the fossil perhaps resembles *Girronniera* most closely. *G. subaequalis* Planch. is of similar size and is much compressed. Other species, however, for example *G. nervosa* Planch., are more inflated and more asymmetric, while others are either larger or smaller than the fossil. In spite of the resemblances noted, the fossil cannot be identified with *Girronniera* because the surface of the endocarp is more coarsely pitted in this genus and the outlines of the pits are digitate. Thus whilst we consider it probable that the fruit belongs to the Urticaceae, we are not able to assign it to any living genus. We have therefore placed it in a form-genus, *Urticicarpum*, to indicate its probable affinity.

We may perhaps, in passing, draw attention to the fact that the Anemoneae, with which group of Ranunculaceae comparison was made above, are essentially temperate in their distribution, whereas many of the Urticaceae are tropical. In view of the overwhelming evidence as to tropical affinities disclosed, almost without exception, by the London Clay fruits, when their relationship is known, we consider that the living distributions of the two families affords confirmatory evidence in favour of relationship to the Urticaceae rather than to the Ranunculaceae.

V. 22133 Holotype, figured Pl. III, fig. 14. A fruit. *Reid & Chandler Coll.*, Minster, 1929.

Family OLACACEAE

Genus ERYTHROPALUM Blume

1826. Bijdr. Fl. Nederl. Ind., p. 921.

Erythropalum europaeum n. sp.

Plate III, figs. 15–17.

1879. *Nelumbium Buchii* Ettingshausen, p. 395.

Diagnosis.—Endocarp ovoid, woody, dehiscing at the apex into three valves, formed of parenchyma, the internal surface covered with coarse fibres which run longitudinally below, but form a coarse apical network. Seed ovoid; testa cells small, inflated, flat-topped, and angular, grouped into polygonal areas. Distinguished from living species seen by us by its small size and broad form. Length from 9 to 11 mm.

Holotype.—V. 22134.

Description.—*Endocarp:* One-loculed, one-seeded, ovoid, with a small circular scar of attachment, woody, formed of parenchyma, each cell being about 0·03 mm. in diameter; splitting into three valves at the apex, as indicated by the presence of a triradiate ridge of pyrites (Pl. III, fig. 17). Surface of locule ornamented with a coarse network of flat fibro-vascular strands which diverge from the base, and converge to the apex. The branching and anastomosing of these strands is such as to produce long parallel-sided meshes on the lower part of the locule wall, and large, equiaxial, sub-hexagonal, or lenticular, meshes towards the apex (Pl. III, figs. 15, 16). The surface between the meshes is formed of polygonal cells each about 0·025 mm. in diameter. Length of locule-cast, 9 to 11 mm.; diameter, 7·5 to 9·5 mm.

Seed: Conforming in shape to the locule. Testa formed of small, inflated, flat-topped, angular cells, about 0·012 to 0·013 mm. in diameter. The cells appear to be arranged in polygonal groups about 0·05 mm. in diameter. No seed was exposed sufficiently to permit of measurement.

Remarks.—Six specimens. In one only is a great part of the endocarp preserved, and even in that the surface is much worn; the other five are internal casts of locules with remains of the carpel still adhering. Two of the specimens are so worn or broken as to display the cast of the seed lying within (cf. Pl. III, fig. 16); in both it is somewhat shrunken, and is separated from the locule wall by pyrites. The triradiate ridge at the apex of some of the fruits was formed by infiltration of pyrites into the incipient cracks associated with dehiscence. Subsequently the hardened pyrites remained as ridges when the softer endocarp surrounding it had been removed by abrasion.

Affinities.—The ovoid, single-seeded endocarps, with the characteristic network of fibres on the internal surface, are typical of the family Olacaceae, the endocarps of *Schoepfia* Schreb., *Olax* Linn., and *Erythropalum* Blume being most comparable with the fossils. Those of *Schoepfia* may be quite small (*S. jasminodorea* Sieb. & Zucc., length, 7·5 mm.), but as the internal fibres do not anastomose at the apex in the same marked manner, they are excluded from comparison. In *Olax*, the fibres are covered by a relatively thick coat of thin-walled loose-textured cells which adhere firmly to them. The testa cells are unlike those of the fossil. In *Erythropalum* the tissue covering the fibres internally forms a uniform thin coat which is easily detached; it would probably decay readily in fossilization. The apparent grouping of the testa cells in the fossil is probably due to the superposition of the impression of a similar coat, which has now disappeared, upon the cells of the testa. We were able to dissect and examine in detail the fruit of *E. scandens* Blume. On removal of the thin-walled tissue from the interior of the endocarp of this species an arrangement of fibres identical with that of *E. europaeum* was seen. Moreover, the testa cells are exactly comparable and are similarly grouped in the two species. The fruits of *E. scandens* are usually much larger and more elongate than the fossil, but they vary considerably in size; one measured only

12 mm. In view of the close resemblances between the fossil endocarps and those of the living genus *Erythropalum*, the only differences being in size and form, we refer the fossils without any hesitation to that genus. The living species are tropical climbers with a distribution from south China, through Further India and the Malay Peninsula, to Java.

A much worn locule-cast of *E. europaeum* was labelled by Ettingshausen "*Nelumbium Buchii*." It is 11 mm. in length, 9·5 mm. in diameter. Remains of about five or six of the longitudinal strands of fibres are preserved, but otherwise the endocarp is completely decayed or abraded. The cast of the contained seed is exposed on one side of the specimen ; it shows clearly the well-preserved, minutely tessellated surface of the testa. The specimen is deeply indented, and had evidently been much battered prior to fossilization. The structure of the longitudinal strands of fibres and of the testa cells affords conclusive proof that it is not *Nelumbium ;* no such fibres or cells occur in the seeds of that genus. Ettingshausen appears to have been misled as to the identity of the specimen by its superficial appearance and shape. Another broken and abraded locule-cast in a jar labelled "*Trinax Bowerbankii*" by Ettingshausen appears to belong to this species. It was associated with three fruits of *E.* (?) *striatum*, the species next to be described.

V. 22134 Holotype, figured Pl. III, figs. 15, 16. A locule-cast, broken on one side so that it shows the internal cast of the contained seed.
V. 22135 Figured Pl. III, fig. 17. A locule-cast with remains of the carpel wall adhering. It shows the triradiate pyrites ridge marking the lines of dehiscence.
V. 22136 An endocarp, somewhat abraded, but with much of the wall still preserved.
V. 22137 Two locule-casts.
V. 22138 A much abraded locule-cast, enclosing a seed-cast. Labelled by Ettingshausen "*Nelumbium Buchii* Ett."
V. 22139 A locule-cast, broken into two, and much abraded. Labelled "*Trinax Bowerbankii*" by Ettingshausen.

All from the Bowerbank Coll., Sheppey.

Erythropalum (?) *striatum* n. sp.

PLATE III, figs. 18–20.

DIAGNOSIS.—Endocarp one-loculed, one-seeded, dehiscing at the apex into three valves, woody, formed of two coats of parenchyma, within the substance of the inner coat and on its outer surface coarse fibres are embedded, aligned longitudinally below but forming a close network above. Seed ovoid, anatropous ; testa of uniform, inflated, quadrate cells. Distinguished from *E. europaeum*, and from all living species seen by us by its small size and the fineness of the network. Length, 6 to 8 mm.

HOLOTYPE.—V. 22140.

DESCRIPTION.—*Endocarp :* One-loculed, one-seeded, ovoid, splitting into three at the apex (Pl. III, fig. 19) as in the preceding species, woody, the external layer formed of fine parenchyma with cells about 0·025 mm. in diameter. Within lies another parenchymatous coat with more or less longitudinally aligned cells. Numerous longitudinal strands of fibres are embedded in this coat and lie upon its outer surface ; they arise from the raised margin of a slightly sunk, circular, basal scar of attachment. The scar is pierced by about five or six strands of fibres near its periphery. The longitudinal fibres, as they pass upwards, give rise to anastomosing branches ; within the thickness of the wall they form a complex network with small, close, approximately equiaxial meshes around the apex, and below, larger and more elongate meshes (Pl. III, figs. 18–20). Length of endocarp, 6 to 8 mm. ; diameter, 5 to 6 mm.

Seed: Ovoid, anatropous. Testa formed of small uniform quadrate cells, sometimes much inflated so that they give rise to a finely granulate or papillate surface. The cell outlines were difficult to see, but in one specimen the diameter was about 0·012 mm.

REMARKS.—Twenty-one specimens. We were at first doubtful whether all should be referred to the same species, but after a detailed examination we reached the conclusion that the apparent differences in coarseness and complexity of the network of fibres was not specific, but resulted from the varying degrees of abrasion which the specimens had undergone. When abrasion is slight the surface may appear almost fluted or ribbed below, with pronounced longitudinal fibres, and with coarse obscure meshes at the apex. With progressively greater abrasion, the network is more and more exposed and appears to become closer and more complicated ; the longitudinal ribbing disappears except at the base, and the meshes diminish in size. Seeds were seen in two specimens only, prior to fracture. Over the surface of one seed, and exposed in longitudinal section in another, there is a longitudinal strand of fibres which probably represents the raphe.

AFFINITIES.—The form, the character of the endocarp with its fibres and parenchyma, and the character of the testa place these specimens in the family Olacaceae. They most resemble the genus *Erythropalum*, but no living species seen by us has such small fruits or such a fine fibrous network in the endocarp. The reference to the genus is therefore doubtful, but all the characters in living and fossil endocarps are closely comparable, although on a different scale in the two cases. Of four specimens labelled by Ettingshausen " *Trinax Bowerbankii*," three must be referred to *E.* (?) *striatum* and one broken specimen to *E. europaeum*. Two other specimens, which he labelled " *Sabal* sp. ", must be referred to *E.* (?) *striatum*.

V. 22140 Holotype, figured Pl. III, fig. 19. An endocarp (compressed at the base), which has been more abraded at the apex than below. Hence below it shows hints of longitudinal ribs and fibres, and above the fine close network of fibres. The three-rayed ridge, indicating dehiscence, is also visible at the apex.
V. 22141 Figured Pl. III, fig. 20. A worn endocarp, showing the fine network of fibres over the apex.
V. 22142 Figured Pl. III, fig. 18. A worn endocarp, showing the fine network of fibres over the sides.
V. 22143 Four fruits in varying stages of abrasion. Two are fractured longitudinally.
V. 22144 Three fruits, two of which show the seed. Labelled " *Trinax Bowerbankii* " by Ettingshausen.
V. 22145 Two much worn endocarps, the bases of which are completely abraded. Labelled " *Sabal* sp. " by Ettingshausen.

All the above are from the Bowerbank Coll., Sheppey.

V. 22146 Nine fruits and endocarps. *Reid & Chandler Coll.*, Minster, 1929.

Genus OLAX Linnaeus

1747. Diss. Dass., p. 3.
1749. Amoen. Acad., i, p. 387.

Olax depressa n. sp.

PLATE III, figs. 21, 22.

DIAGNOSIS.—Endocarp hemispherical, ventrally depressed, formed of parenchyma with embedded fibres which form a complicated network. Slightly smaller than the endocarps of *O. subscorpioidea*. Length, 5 mm.; breadth, 10 mm.

HOLOTYPE.—V. 22147.

DESCRIPTION.—*Endocarp:* One-loculed, one-seeded, hemispherical, dorsal surface convex, ventral surface with a shallow circular depression. A sub-circular patch of pyrites at the apex may mark the limits of the persistent superior perianth. Endocarp wall with an external layer of parenchyma followed within by a coat of finer parenchyma (many of the cells are 0·014 or 0·015 mm. in diameter) in which are embedded fine strands of fibres, which run from base to apex, branch and anastomose to form a complicated coarse network (Pl. III, fig. 22). Seed solitary, testa much decayed. Length of endocarp, 5 mm.; diameter, 10 mm.

REMARKS.—Two poorly preserved specimens, with the same hemispherical shape and large basal depression. The walls of the endocarp are highly pyritized and much abraded, the locule is filled with crystalline pyrites, the decayed testa being embedded within it. The external parenchymatous coat is largely abraded, but can be seen immediately around the apical patch of pyrites, which has served to protect it. Its structure is obscure. The surface beneath it is covered by a network of cracks filled with pyrites; some of the apparent cracks on close inspection can be seen to be the tracks of fibres, now decayed. Here and there these fibres are still preserved, forming a network. In one place where the pyritized wall is broken a longitudinal strand of similar fibres is visible within. It may possibly represent an inner coat of fibres.

AFFINITIES.—The depressed form of the endocarp, and the presence of the fibres within its walls, caused us to compare it in the first instance with the Myrsinaceae. But the fibres in Myrsinaceae form much flatter, broader strands than those in this fossil. Also they do not branch and anastomose so freely. Consequently they form slightly branching longitudinal ribs, rather than a network. We next compared it with Olacaceae. In this family many endocarps show similar parenchyma and fibrous ribbing, but almost all are ovoid and longer than broad. The fruits of *Olax subscorpioidea* Oliv. are, however, similar in size, shape, and relative proportions. There can be no doubt therefore as to the affinity of the species. The various species of *Olax* may be trees, scrambling shrubs, woody climbers, or small shrubs three feet high. They are distributed throughout the tropics of the Old World. *O. subscorpioidea* is a small tree or shrub which forms undergrowth in the high forests of tropical West Africa. One specimen from Northern Nigeria, preserved in Kew Herbarium, was stated to range from 3,000 to 4,000 feet.

V. 22147 Holotype, figured Pl. III, figs. 21, 22. An endocarp, now broken in two.
V. 22148 An endocarp, more abraded than the previous specimen.
Both are from the Bowerbank Coll., Sheppey.

Family OLACACEAE ?

A specimen fractured transversely before it came into our hands is probably the locule-cast of one of the Olacaceae. It is ovoid, and shows a pentagonal scar at one end and a triradiate ridge at the other. The outer surface is covered by the impression of parenchyma with an embedded network of coarse fibres such as is characteristic of the inner surface of the endocarps of this family. In a few minute patches the impressions of testa cells remain preserved in granular pyrites. They are very obscure but appear to have been inflated, and oblong or polygonal in shape. Length of cast, 14 mm.; breadth, 10 mm.

V. 22149 An endocarp (internal cast), fractured transversely. *Bowerbank Coll.*, Sheppey.
V. 22150 Half a large fruit, which may belong to the same species. *Bowerbank Coll.*, Sheppey.

Family NYMPHAEACEAE

Genus PROTOBARCLAYA nov.

Diagnosis.—Fruit ovoid, syncarpous, many-seeded, placentation parietal. Seed ovoid, highly spinescent, anatropous, with an embryotega pierced centrally by the micropyle, chalaza at the opposite end. Spines circular in section, but arising from digitate interlocking cells.

Genotype.—*P. eocenica* n. sp.

Protobarclaya eocenica n. sp.

Plate III, figs. 23–28.

Diagnosis.—That of the genus.

Holotype.—V. 22151.

Description.—*Fruit:* Ovoid, syncarpous, three-loculed (in the holotype the inner angles of the two best preserved locules measured respectively 110° and 130°, leaving 120° for a third locule), many-seeded, placentation parietal over the whole dorsal surface. Exocarp leathery (?), formed of two coats: the outer consisting of many layers of elongate cells interspersed with bundles of spirally thickened fibres; the inner showing on its inner surface many smooth convex clusters (measuring from 0·02 mm. to 0·5 mm. in diameter) of cells so arranged that they radiate from centres within the thickness of the coat (possibly they may have formed air-spaces for purposes of flotation). Endocarp reaching to the centre of the fruit and incurved at the inner angles of the locules, compact, formed of two coats; the outer of these (which may measure 0·6 mm. in thickness) is formed of polygonal prismatic cells (0·02 mm. in diameter) which are radially aligned so as to give a columnar appearance in radial sections of the fruit; the inner coat (about 0·05 mm. thick) constitutes the locule-lining; it is formed of several thicknesses of cells which in longitudinal sections of the fruit present a columnar arrangement, and over the smooth and shining surface of the locule are seen to be elongate with their longer axes transverse or oblique. Length of fruit, about 18 or 20 mm. (but it fell to pieces before it could be measured accurately or photographed). Length of locule, about 14 mm.; radius, 5 mm.

Seed: Ovoid, anatropous, with a large, circular embryotega at the broad hilar end (which is that turned towards the exterior of the fruit), and the small chalaza at the opposite narrow end, the lateral raphe is broad and flat, and the micropyle pierces the centre of the embryotega. Surface of the testa highly spinescent, with long tapering spines (from 0·1 to 0·25 mm. in length) arranged in longitudinal rows; those around the embryotega are straight, those over the middle of the seed are usually curved and have their points directed to the hilar end of the seed, those above the middle of the seed (*i.e.* towards the chalaza) are directed towards the chalaza (Pl. III, fig. 25); around the hilar end, at a short distance from the micropyle, they form a close ring which seems to delimit the embryotega; over the micropyle there is a close tuft of long straight spines; each spine on the testa arises from a single quadrangular cell with finely digitate margins, the digitations interlocking with those of the next cells, but close above the base the spines are approximately circular in section, the diameter measuring 0·1 to 0·15 mm.; only over the embryotega are the cells neither digitate nor interlocking, and here they radiate from the micropyle. The tegmen is thin, usually much crumpled and contracted, its cells are extremely thin-walled and therefore very difficult to see, but they appear to be similar in shape and size (0·1 mm. in diameter) to the testa cells, only their margins are smooth, not interlocking. Length of internal cast of seed, 1·5 mm.; diameter, 1 mm.

Remarks.—One fruit, which at first appeared as an ill-characterized oval body. Fortunately the specimen was so badly decayed that, on drying for examination, it fell to pieces, thereby showing that it was a syncarpous, many-seeded fruit. The structure of the exocarp is much obscured by decay; it tends to separate into flaky layers parallel to the surface. As the result of decay of the pericarp the locule-casts were set free with some of the endocarp adhering to them. Each locule-cast is formed of a mass of pyrites in which the seeds are embedded (Pl. III, figs. 23–25), but by the cracking and decay of the pyrites-cast many seeds have been liberated. The preservation of the spines is undoubtedly due to their being closely surrounded with pyrites. When the seeds are liberated some of the testa and the spines usually remain adhering to the pyrites, the seed-cast being the entity which falls free. Hence the external surface of the seed is rarely seen except in section; we were, however, able to observe it in a few specimens, but unfortunately those with complete spines always fell to pieces before they could be photographed. In one specimen on which the testa was preserved the embryotega had fallen out, leaving an aperture with smoothly finished edge. More often the embryotega is indicated merely by a dull circular scar (somewhat like a chalazal scar in appearance) on the internal cast of the seed. Occasionally the edges of this scar are sunk, especially on those casts to which the remains of the testa still adhere. The chalaza is indicated by a thickening of the testa over the narrow end of the seed, and by a small internal scar from which the cells radiate ; the raphe is a well-defined flat strand of fibres lying in the thickness of the testa. The interlocking walls of the testa are difficult to observe because, when the testa separates from the seed-cast, as a rule the spines break off just above their bases at a point where they are circular in section, the digitate cells from which they arise not being seen. Hence the surface of the testa appears in such specimens to be composed of circular smooth-walled cells filled with glistening pyrites. It is only in true internal casts of the seed-cavity that the interlocking cell walls can be seen, but even in these the impressions of the cells are often not sufficiently sharp to show the digitations.

Affinities.—The character of the regularly ovoid anatropous seeds showing embryotegas pierced by the micropyle, and digitate cells in the testa, leaves no doubt as to the affinity of this species with the family Nymphaeaceae, whilst the syncarpous, many-loculed, many-seeded fruits with parietal placentation and seeds attached over the whole dorsal surface, suggests alliance with the section Nymphaeoideae. This alliance is strongly supported by the character of the spinescent seeds, which closely resemble those of *Barclaya* Wall, to which genus, there can be little doubt, the fossil is most nearly allied. The only difficulty is that all living genera belonging to the section Nymphaeoideae have a greater number of locules than are found in the fossil (three). The smaller number of locules is found in the section Cabomboideae of the family, therefore it does not exclude alliance to the family ; whether it should be regarded as excluding it from the Nymphaeoideae and call for the creation of a new (extinct) section of the family remains undecided. We have named the species *Protobarclaya eocenica*.

The genus *Barclaya* to which it is allied inhabits running and stagnant fresh water in the tropics of Eastern Asia. Its fruits are about 14 to 18 mm. long, and 13 to 18 mm. broad.

V. 22151 Holotype, figured Pl. III, figs. 23–28. A fruit (now decayed and fallen to fragments) with many seeds. *Bowerbank Coll.*, Sheppey.

V. 22151*a* A locule-cast from the holotype, illustrated (Pl. III, fig. 23) to show the dorsal side.

V. 22151*b* A second locule-cast from the holotype, illustrated (Pl. III, fig. 24) to show the ventral side, and again illustrated (dorsal side, Pl. III, fig. 25), after further disintegration had occurred, to show the seeds and their spines embedded in the pyrites which filled the locule.

V. 22151*c* An isolated seed-cast from the holotype, figured (Plate III, fig. 28) to show the form.

V. 22151*d* A second seed-cast isolated from the holotype, figured (Pl. III, fig. 26) to show the scar of the embryotega. This is also well shown in another isolated seed-cast (V. 22151*e*).

V. 22151*e* The seed figured Pl. III, fig. 27, has now decayed. It showed the bases of the spines adhering to the remains of the testa which covers the seed-cast.

Family TROCHODENDRACEAE

Genus TROCHODENDRON Siebold & Zuccarini

1835. Fl. Japon., I, p. 83.

Trochodendron (?) pauciseminum n. sp.

PLATE III, figs. 29–33.

DIAGNOSIS.—Fruit fusiform (?), syncarpous, six- (or five- ?) loculed, dehiscing septicidally. Each carpel cuneate in transverse section, slightly convex transversely and strongly convex longitudinally on the dorsal face, lined laterally by straight, and dorsally by contorted fibres. Seeds few, long and thin, raphe forming a long appendage. Testa of three coats: the outer formed of long, narrow, straight cells except over seed-body, where they are shorter and irregular, the inner coats producing ripple-like markings over the seed-body.

HOLOTYPE.—V. 22152.

DESCRIPTION.—*Fruit:* Broadly fusiform (?) when perfect, a six- (or five- ?) carpelled capsule, dehiscing septicidally. A single locule-cast, which is the only one that has been preserved, is partly covered by the remains of the septa; it is cuneate in transverse section with the dorsal face slightly rounded, and the ventral faces flat; in profile it shows the ventral margin straight below, but obliquely truncate above, and the dorsal face highly convex from base to apex, but not forming a smooth curve, there being a marked inward bend above the middle; here also the face narrows slightly, so that the apex of the fruit must have been flatter than the base (Pl. III, fig. 29). The impressions and remains of the septa show that their inner surfaces were formed by a flat coat of fibres which conform in direction to the direction of the margin to which they are nearest, straight near the ventral margin, curved near the dorsal. The dorsal surface shows impressions of the cells forming the inner layer of the pericarp; these indicate elongate cells (fibres ?) very variously oriented so as to produce a confused and tangled appearance. The coats outside this have been worn away. Length of locule, 5·75 mm.; radial thickness, 2·2 mm.; tangential thickness, 2·25 mm.

Seeds: Few, certainly two, probably more; their exact form cannot be seen, but it is clear that they are elongate, and aligned longitudinally in the locule (Pl. III, figs. 32, 33), also that they are formed of a seed-body and a long apical appendage. The seed-body is thin and slightly lunate in transverse section. The testa shows three coats over the seed-body, and one only, the outer, over the appendage. The outer coat is formed externally of long parallel-sided cells aligned longitudinally over the enlarged raphe (?) which appears strongly striate; one of these cells measured 0·3 × 0·07 mm.; others are longer, but the exact length could not be ascertained. Over the body of the seed they are shorter, broader, and more irregularly aligned so as to give a netted appearance. This coat is produced beyond the body at the apical end of the fruit to form the long appendage. Over the body of the seed within the coat just described are two others; the outer of these is formed of small, elongate, longitudinally aligned cells, each about 0·05 × 0·016 mm., and the inner of quadrangular cells aligned in longitudinal rows, each cell about 0·1 mm. broad and 0·05 mm. long (Pl. III, figs. 31–33). The two coats together produce the effect of a rippled striate surface to the seed-body.

REMARKS.—One locule-cast, showing on its lateral walls the impression and some remains of the septa, and on its dorsal surface the impression of the tangled cells belonging to the inner layer of the endocarp. The ventral angle of the locule indicates that there were probably six such locules in the perfect fruit. The change in curvature of the dorsal surface indicates that the apex of the fusiform fruit must have been somewhat flatter than the base. Although there were indications of the cells of the testa beneath the locule-lining it was impossible to understand completely, without fracturing the specimen, what was the structure of the seed, or to find the relationship of the fruit. The carpel was therefore fractured, the fracture running obliquely-longitudinally. Two seeds were then seen but were not completely exposed, one being broken across. It is not possible to make certain without further fracture whether the seeds which are shown in part on the outer surface are the same as those seen inside; but most probably they are not. The evidence for septicidal dehiscence is found in the impression of the smooth septa continued to the inner angle of the carpel, and in the absence of any sign of a longitudinal median fissure on the dorsal surface, or of a longitudinal median line from which the cells diverge, such as would occur were dehiscence loculicidal.

AFFINITIES.—The fundamental facts on which we based our search for the relationship of this specimen were that it was a single locule of a septicidal many-seeded capsule, that the probable number of locules was six (or perhaps five) and that the seeds were elongate with an apical appendage. These characters greatly restricted the possible relationships. Nevertheless, we examined every species in our seed collection and all our drawings of living fruits and seeds, and found that *Trochodendron* alone possessed the required characters. A study of this monotypic Japanese genus showed that it can have the same number of locules, for in the living species the carpels range from five to nine. The shape of the carpel is almost identical in fossil and living, but the fossil is slightly larger. The cells which constitute the locule-lining are identical in both. The fruit of *T. aralioides* is sunk in the enlarged receptacle, but the locules break from one another septicidally, and the septa are continued to the axis of the fruit. So far as the fossil material permits of comparison, the only essential difference lies in the seeds. In *T. aralioides* these are numerous in each locule, and linear. The body of the seed is masked by the comparatively much larger and longer raphe to which it seems to form a mere lateral excrescence, the raphe forming long appendages at both ends. The testa is formed of narrow, elongate cells. Over the raphe these are very long and narrow, so that it appears striate. Over the seed-body they are much shorter and more tortuous. Hence the outer coat of the testa bears a strong resemblance to the same coat in the fossil. It is produced beyond the seed-body at both ends—hilar and chalazal—forming two appendages. We were unable to separate the inner coats in the living seeds; therefore, we could not compare them. The essential difference between the seeds of the fossil and living species lies in the former being larger and fewer than in the latter. In view of the close correspondence in the character and structure of the fruit as deduced from its locule-cast, in the form and arrangement of the seeds, and in the character of the testa, we think that the fossil should certainly be referred to Trochodendraceae, and that it must be closely related to *Trochodendron*, if it does not actually belong to the genus. But the evidence is insufficient to demonstrate the relationship in all details of the pericarp and accrescent receptacle (if there ever were such), since these are not preserved. We have therefore queried the reference to the genus *Trochodendron*.

V. 22152 Holotype, figured Pl. III, figs. 29–33. A locule-cast with seeds. *Bowerbank Coll.*, Sheppey.

Family MENISPERMACEAE

The family Menispermaceae is well represented by seven species belonging to six genera. In this family the endocarps of all species, whether living or fossil, are very characteristic, and therefore easily determinable. In all, the woody endocarp is bent, and the seed, which fills the locule, is bent in accordance. The bending may be of different kinds.

In a large number of genera, the elongate endocarp and seed are bent longitudinally more or less into a horse-shoe shape, the plane of symmetry cutting the margin medianly. In such fruits the space between the limbs is occupied almost to the centre by a flange-like extension of the endocarp so that the endocarp in transverse section is somewhat dumb-bell shaped, but the connecting arm is interrupted at the middle (Pl. IV, fig. 18). In some genera the lateral hollows on either side of this plate are filled by part of the endocarp, as in the living *Tiliacora* Colebr. and the fossil *Bowerbankella*; in others they remain empty, as in the living *Hypserpa* Miers and *Menispermum* Tournef. When endocarps of the latter type are fossilized the hollows may be filled with matrix, thus in *Eohypserpa* they are filled by hard plugs of pyrites. These plugs gave us great trouble at first because, being covered with the adherent cells of the endocarp, and having a very definite form, we interpreted them as organic parts of the fruits, whereas they are nothing of the kind.

Other genera of Menispermaceae have the endocarp bent into more or less of a boat-shape. In some, for example, the living *Tinomiscium* Miers, and the fossil genera *Tinomiscoidea* and *Microtinomiscium*, the endocarp and seed are straight from base to apex, but somewhat concavo-convex from side to side in transverse section; in such forms the boat-shape is very shallow (Pl. IV, figs. 1, 4, 5). In other genera, *e.g. Tinospora* Miers, the curvature is in both directions. The endocarp and seed are then deeply boat-shaped (Pl. IV, figs. 7–12). But whatever the special modifications, the form, and frequently the sculpture, are so remarkable that it is very easy to recognize members of this family.

We have mentioned six fossil genera and seven species, although on our list we record but five genera and six species. The reason is that one of the figures in Crow's Manuscript Catalogue (1810, No. 656) unmistakably represents a species belonging to the family, but one which we have never seen. He states that it is " very rare, the only one I ever saw." The endocarp is bent horseshoewise, somewhat flattened, and with characteristic ribbed or fluted sculpture at the margin such as occurs in many living genera (*e.g. Menispermum* Tournef.), and is also seen in the locule-cast, but not on the endocarp, of the fossil genus *Bowerbankella ;* the form is more elongate than *Bowerbankella* and the two limbs differ from one another in outline, one being slightly concave along the margin towards the base, the other convex along the whole margin. Therefore, it cannot represent a locule-cast of *Bowerbankella*. The drawing suggests affinity with various living genera, but without the specimen it would be idle to seek generic affinity.

It is a fact of great importance that in a family with such striking characters of the endocarps as the Menispermaceae, one in which it is comparatively easy to trace generic relationship, four out of the five determined genera have proved to be extinct. The Menispermaceae therefore illustrate facts to which we have already drawn attention in the Introduction (pp. 40–44, 69–70). In the first place, that a very large proportion of the London Clay genera are extinct ; in the second place, that, although extinct, they can nevertheless be referred in many cases with great certainty to living families ; and, in the third place, that genera found fossil in the same deposit, whether living or extinct, bear the same evidence, the one as the other, to the geographical distribution of the living allies and the past climatic conditions. So that fossil genera and species can give a true index of climate.

Section I. *TRICLISIEAE* Diels

Genus BOWERBANKELLA nov.

Diagnosis.—Endocarp, woody, obovoid, smooth externally, curved longitudinally with a sub-marginal horse-shoe shaped groove on each face, dehiscing into symmetrical halves with flattened internal faces, one-loculed, one-seeded. Style sub-basal. Locule and seed horse-shoe shaped, laterally compressed, ornamented with a regular, conspicuous series of alternating tubercles and hollows. Seed anatropous.

Genotype.—*B. tiliacoroidea* n. sp.

Bowerbankella tiliacoroidea n. sp.

Plate III, figs. 34–41 ; text-fig. 2.

1879. *Menispermacites abutoides* Ettingshausen (pars), p. 394.

Diagnosis.—That of the genus.

Holotype.—V. 22153.

Description.—*Endocarp :* One-loculed, one-seeded, obovoid, elongate but bent longitudinally into a horse-shoe shape, the lateral hollows between the limbs being filled by thick plugs; with a marked bisymmetry about a plane passing through a median marginal groove, along which it dehisces into equal solid hemispherical valves, the inner faces of which are flattened but not smooth. Attachment at the narrow end. The convex outer face of each valve is marked by a conspicuous horse-shoe shaped furrow enclosing an area (the plug) which overlies the cavity of the curved locule. The horse-shoe is slightly asymmetric at its free ends which lie at the narrow base of the endocarp. One end passes to the sub-basal style, the other curves outward to the basi-lateral attachment (Pl. III, figs. 34, 35).

The flattened inner face of each valve has a highly ornamental surface (Pl. III, figs. 37, 38); a horse-shoe shaped ring of large tubercles, about eighteen in number, with corresponding hollows between, surrounds a slightly elevated flat surface. This is in contiguity with the corresponding surface of the other valve, and together they form a condyle around which the horse-shoe shaped locule and seed are curved. At the centre of the condyle is a small curved cavity, due probably to incomplete fusion of the two limbs. In the living Menispermaceae, the funicle enters the locule through this aperture. Outside the ring of tubercles is a broad flat margin (Pl. III, figs. 37, 38). The horse-shoe furrow on the external surface marks the outer limit of a plane of weakness, nearly at right angles to the internal surface of the valve,

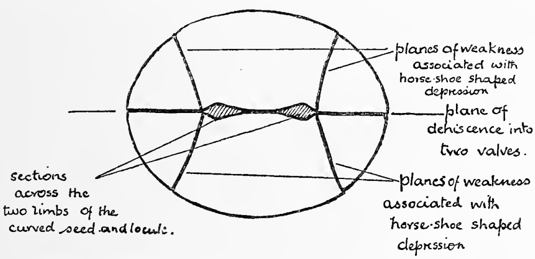


FIG. 2.—Diagrammatic transverse section across an endocarp of *Bowerbankella*.

along which further dehiscence takes place, at least in fossilization (Pl. III, fig. 37; text-fig. 2). The inner limit of the plane corresponds with the inner limit of the ring of tubercles; the outer limit of the plane overlies the outer limit of the same ring. Consequently the plane slopes towards the middle of the horse-shoe so that the internal surface delimited by it is smaller than the external; the structure is probably concerned in some way with dehiscence and germination.

The walls of the endocarp are thick, formed in part of woody fibres. One section shows a mass of radially directed coarse fibres, between which are lacunae now filled with structureless pyrites, which may, in part at least, replace parenchyma, of which patches are still preserved. Towards the locule the wall is formed of closer, finer fibres which radiate outwards from the centre of curvature of the endocarp. This layer passes not only between the flat marginal surfaces along which the two hemi-spherical valves meet, but also along the horse-shoe shaped planes of weakness in each valve described above (text-fig. 2). The locule-lining itself is smooth, formed of several layers of variously directed fibres which give a criss-cross effect. The funicle passes through the condyle to the placenta, which is excentric on the inner curve of the horse-shoe shaped locule. The stylar canal is funnel-shaped. Adjacent to, and almost parallel with, the stylar canal there is a groove probably also connected with the incomplete fusion of the limbs of the curved endocarp (Pl. III, fig. 39). Length of endocarp, 8·5 to 10·5 mm.; breadth, 6·25 mm.; thickness, 7 to 8·25 mm.

Seed (Pl. III, figs. 39–41): Represented by its internal cast in golden pyrites; not ruminate, horse-shoe shaped, conforming to the shape of the locule, flattened, but rather thicker towards the external margin where it is boldly ornamented with about eighteen alternate hollows and ridges. Anatropous, hilum on the inner curve of the margin of the seed, slightly excentric; from it a band of fibres, the raphe, runs along the inner curve. Testa formed of regular, polygonal cells, those of the external surface being smaller than those of the internal surface, which are about 0·02 to 0·03 mm. in diameter. Length of seed, 5 mm.; breadth, 4·5 mm.

REMARKS.—Four specimens, which were originally intact; later some of them fell to pieces as the result of decay, thereby revealing structures previously unsuspected. Also one endocarp, much worn and abraded, collected by ourselves at Minster.

The interpretation of this beautiful species was at first difficult owing to the curious effects of disintegration. When the endocarp splits into two valves, the cast of the locule tends to fall free with the carbonized inner layers of the endocarp adhering firmly to it; also it carries with it, as a thin marginal flange, the innermost layers of the flat peripheral region surrounding the tubercles and the locule cavity. But that extension of the innermost layers which passes along the horse-shoe shaped plane of weakness in each valve, as described above, being approximately at right angles to the locule, cannot free itself in the same way and it is therefore torn at the surface of the locule-cast. Its ragged edges appear immediately within the ring of tubercles. When, as in one specimen, the locule-cast chips away, the internal cast of the seed is seen inside, with the impression of the testa cells upon it (Pl. III, figs. 39, 41).

AFFINITIES.—The remarkable structure of this fossil leaves no doubt at all that it belongs to the family Menispermaceae and to the section Triclisieae of Diels (1910). The peculiar form and sculpture of the locule and seed are conclusive. All sections of the family with straight endocarps can at once be discarded in considering affinities, so that no account need be taken of the sections Penianthеae, Fibraureae or Tinosporeae. The Anomospermeae can likewise be discarded on account of their form and their conspicuous horizontally laminated albumen; nor are the Hyperbaeneae comparable, for their sole representative, the American genus *Hyperbaena*, has an endocarp and seed which bear very little resemblance to the fossil. There remain the three groups Cocculeae, Anamirteae, and Triclisieae.

The Cocculeae are distinguished by their highly ornamental and compressed endocarps; whereas the endocarp of *Bowerbankella* is inflated, and not ornamented on the exterior. However, the locule and seed have the compressed form which characterizes this section of the family.

The Anamirteae are a small section with thick bony endocarps, but these do not bear any resemblance to the fossil, as they have no external horse-shoe shaped areas and associated planes of weakness, the form of the locule is entirely different and the surfaces of locule and seed are less highly sculptured.

The Triclisieae have curved and inflated endocarps with sub-basal styles, conspicuous thickened condyles, and horse-shoe shaped seeds. Endocarps of comparable form, with thick woody walls formed of radiating fibres and parenchyma are found in *Tiliacora*. *T. Dielsiana* Hutch. & Dalz. dehisces into two hemispherical valves each of which has an external horse-shoe shaped ornamentation similar to that seen in the fossil. The locule-lining is of similar structure ; so also is the testa. It is difficult to know whether the differences between this species and the fossil are specific or generic in character. The endocarps of *T. Dielsiana* are usually larger than those of the fossil (13 × 10 × 10 mm. to 17 × 16·5 × 16 mm.) ; the outlines of the external horse-shoe shaped areas, instead of being smoothly curved, are sinuous ; the locules, instead of being shallow and compressed, are deep ; and, in consequence, the seeds, instead of being much compressed, are inflated ; whilst the rows of marked tubercles seen in the fossil are represented merely by undulations of the surface. Although, on account of its thick endocarp, *T. Dielsiana* perhaps comes nearest to the fossil, other species more resemble it in size and in the sculpture of the seed. Thus *T. triandra* Diels measures 8·25 × 7 × 6 mm. (a typical specimen), and the undulations of the locule and seed, although fewer than the corresponding tubercles in the fossil, are much more marked than in *T. Dielsiana*. A difference which may be noted in passing between the seeds of the two living species mentioned above, is that those of *T. triandra* are ruminate, whereas those of *T. Dielsiana* are not. It is a difference regarded by Diels as of specific value only.

Thus comparison with the genus *Tiliacora* reduces the differences between its various members, on the one hand, and the fossil, on the other, to the following : the greater inflation of the seeds and locules of *Tiliacora*, the absence of any species in the genus with regular tubercles, the wavy contours of the horse-shoe areas in the living endocarp and the more ornamental character of its external surface. These differences, more especially those relating to the thickness and tuberculation of the seed, are greater than any we have noted in a single living genus of Menispermaceae. They therefore suggest that the fossil belongs not to *Tiliacora* but to a closely allied genus of the Triclisieae. *Tiliacora* itself is a genus of climbers inhabiting India, Ceylon, Further India, the Malay Peninsula and Islands, and Tropical Africa. *T. Dielsiana* is a native of tropical West Africa.

This fossil is perhaps the most beautiful of the London Clay fruits. We have therefore called it *Bowerbankella tiliacoroidea* in honour of J. S. Bowerbank, the first real student of the London Clay flora. A specimen is illustrated by Crow in his manuscript catalogue (1810, number 464).

Ettingshausen labelled these specimens "*Menispermacites abutoides*." Doubtless he was led to do so on account of the external resemblance to *Abuta* [Barrère] Aubl. which, although larger, has similar horse-shoe shaped furrows on the fruit. But the fruit of *Abuta* is thin-walled, and the seeds are wholly unlike those of *Bowerbankella*. The name appears in his provisional list of Sheppey plants (1879, p. 394) but without figures or description.

V. 22153 Holotype, figured Pl. III, figs. 38–41. An endocarp, which subsequently dehisced as the result of decay, thereby revealing the internal casts of the locule and seed.

V. 22154 Figured Pl. III, figs. 34, 36. An endocarp, now gradually falling to pieces. It shows very clearly the horse-shoe shaped plane of weakness on the external surface.

V. 22155 Figured Pl. III, fig. 35. A fairly well preserved endocarp, showing clearly the structure of the base.

V. 22156 Figured Pl. III, fig. 37. An endocarp, formerly complete but now fallen in pieces as the result of decay, thereby releasing the locule-cast with the inner layers of the endocarp adhering to its surface. The endocarp has broken along the horse-shoe shaped planes of weakness, and has also fractured irregularly in many places.

All the above specimens were labelled by Ettingshausen "*Menispermacites abutoides*." *All are from the Bowerbank Coll.*, Sheppey.

V. 22157 A much abraded endocarp, now in pieces. *Reid & Chandler Coll.*, Minster, 1929.

Section IV. *FIBRAUREAE* Diels

Genus TINOMISCOIDEA nov.

Diagnosis.—Endocarp straight, bisymmetric, shallow, boat-shaped, ventral concavity sharply delimited by faceting of the endocarp wall. Without internal condyle or plate on the ventral surface. Placenta sub-apical, ventral. Locule and seed of similar form to the endocarp. Testa minutely tubercled.

Genotype.—*T. scaphiformis* n. sp.

Tinomiscoidea scaphiformis n. sp.

Plate IV, figs. 1–4.

1879. *Menispermacites abutoides* Ettingshausen (pars), p. 394.
1879. *Elaeis eocenica* Ettingshausen (pars), p. 393.

Diagnosis.—That of the genus.

Holotype.—V. 22158.

Description.—*Endocarp:* One-loculed, one-seeded, straight, elongate-obovate, shallow boat-shaped, slightly convex dorsally and concave ventrally, with a narrow faceted margin which meets the ventral face in a sharp angle and the dorsal face in a smooth curve; bisymmetric about a median dorsi-ventral plane through the longer axis, marked by a slight ridge on the locule-cast (Pl. IV, figs. 1–4). Endocarp carbonized, consequently much abraded, formed of coarse matted fibres (Pl. IV, fig. 1); locule-lining of fine fibres or elongate cells variously aligned, producing in parts a criss-cross appearance and in others a "finger-print" effect. In the main these fibres diverge obliquely from a median line, marked, both on the dorsal and ventral sides, by an internal groove (represented by a ridge on the locule-cast). There is no internal condyle or plate on the ventral face. Placenta median and sub-apical on the ventral face (Pl. IV, figs. 1, 4).

Seed: Of a similar form to the nut, although it has usually collapsed and shrunk from the locule wall, pendulous, anatropous, with median ventral raphe. Testa very thin, closely covered externally with minute tubercles, lined with a delicate layer of large, thin-walled amoebiform cells. Length of longest locule-cast (virtually of seed), 23 mm.; breadth, 10·5 mm. Length of shortest, 16·5 mm.; breadth, 11 mm.

REMARKS.—Four locule-casts, one of which was broken so that the seed was exposed; another was much abraded; the remaining two were perfect. The larger of these (Pl. IV, figs. 1, 2) had a thick patch of the endocarp adhering, but this has since gradually crumbled and fallen away. The smaller of them was fractured, and it then displayed, in section, the thin testa with its tubercled surface and its inner layer (tegmen ?) of amoebiform cells; this layer is always preserved as an impression on the glistening surface of the pyritized internal cast of the seed, the cell-walls being emphasized by the remains of black carbonaceous matter.

AFFINITIES.—The peculiar boat-shape of the fossil at once suggests that its nearest allies are to be found in the section Fibraureae Diels of the family Menispermaceae. So far as can be judged, *Tinomiscium* Miers has the greatest general resemblance. The nuts of *T. petiolare* (Wall.) Miers are of comparable, but not of identical, size and form with the fossil. They are somewhat larger (two that were measured being respectively 26 × 17 × 6 mm. and 26 × 14 × 4 mm.), and the ventral concavity is shallower and smaller. The margin is not faceted, but meets the ventral face in a smooth curve. In *Tinomiscium*, as in the fossil, the endocarp is composed of matted fibres, but the testa is pitted, not tubercled, externally. We have not seen the inner surface of the testa, nor the tegmen, of any living species. *Burasaia* Thou. is another genus in which the nuts resemble the fossil, but they are thicker dorsi-ventrally, while the ventral concavity is smaller, narrower, and deeper. The endocarps of *Fibraurea* Lour. are also somewhat similar in shape; they are occasionally flattened; but most frequently are very slightly hollowed on the ventral face. Neither of these genera seems to be so closely allied to the fossil as *Tinomiscium*.

Owing to the distinctive characters described above, which are probably of generic value, we have thought it best to give the fossil a new generic name, *Tinomiscoidea*; this, whilst implying its generic distinctness, serves also to indicate its affinity. *Tinomiscium* is a genus of climbers inhabiting the tropics of eastern Asia, from Yunnan to Sumatra and New Guinea; also the Philippines. *Burasaia* occurs in the Mascarene Islands, and *Fibraurea* in Further India and the Malay Islands.

One specimen (V. 22158) was labelled "*Menispermacites abutoides*" by Ettingshausen, but it is not easy to understand the reason for this name, as the straight fruit is totally unlike the curved fruits either of the living *Abuta* or of the fossil *Bowerbankella* (p. 158), which he also labelled "*Menispermacites abutoides*." Another specimen was in a jar with other fruits labelled "*Elaeis eocenica*."

V. 22158 Holotype, figured Pl. IV, figs. 1–3. A locule-cast, with much remains of the carpel wall adhering, but rapidly undergoing decay. Labelled "*Menispermacites abutoides*" by Ettingshausen.
V. 22159 Figured Pl. IV, fig. 4. A locule-cast, originally complete, fractured to show the structure of the contained seed. The tubercled surface of the testa is well seen in section.
V. 22160 An imperfect locule-cast. It shows within a cast of the internal surface of the testa or tegmen.
V. 22161 A much abraded locule-cast (in fragments). It was in a jar, containing a miscellaneous collection of fruits, labelled "*Elaeis eocenica*" by Ettingshausen.

All are from the Bowerbank Coll., Sheppey.

Genus MICROTINOMISCIUM nov.

DIAGNOSIS.—Endocarp straight, shallow boat-shaped, without any internal condyle or plate on the ventral surface, bisymmetric; ventral cavity delimited by rounded margins and divided by a longitudinal ridge flanked or either side by a single row of obscure hollows; dorsal surface with a median and two lateral ridges, alternating with rows of bold hollows, four rows in all; placenta ventral, median, sub-apical; locule similar in form to the endocarp.

GENOTYPE.—*M. foveolatum* n. sp.

Microtinomiscium foveolatum n. sp.

PLATE IV, figs. 5, 6.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22162.

DESCRIPTION.—*Endocarp:* Straight, elongate-oval, bisymmetric about a median dorsi-ventral plane through the longer axis, marked by a conspicuous ridge on both faces, pointed at the stylar end, convex on the dorsal surface in both directions, concave on the ventral surface, but with a conspicuous median ridge which attains its maximum elevation at a point, the placenta, about 2 mm. from the terminal style where the ridge is met by the thick rounded ventral margins. The ventral ridge is closely flanked on each side by a row of about six large shallow circular pits the outlines of which are sometimes indefinite as they tend to become confluent (Pl. VI, fig. 5). On the dorsal side there is a strongly marked median ridge and two less marked lateral ridges; between the median ridge and each of the lateral ridges there is a row of about nine large deep circular pits, and between each lateral ridge and the margin there is a row of about seven pits, smaller, less marked, and less regular than those of the other rows (Pl. IV, fig. 6). There is no trace on the cast of an internal ventral condyle or plate. The remains of the endocarp, and the impressions of cells seen on the internal cast, show that the carpel must have been formed of layers of small fibres often tending to produce a criss-cross structure. Locule of same form as endocarp. Length of locule-cast, 8 mm.; breadth, 3·5 mm.; thickness, 2 mm.

Seed: The seed has not been seen except in one small patch, near the placenta, where the pyrites has chipped away, showing a fragment of testa. This appears to be rugose and formed of digitate interlocking cells.

AFFINITIES.—The form and structure of the specimen leave no doubt that it belongs to the family Menispermaceae, and to the section Fibraureae in which the endocarps are straight and the style apical. It is probably related to *Tinomiscoidea* (see p. 162) but is much smaller and more ornate than *T. scaphiformis*. We have therefore given it the name *Microtinomiscium foveolatum*.

V. 22162 Holotype, figured Pl. IV, figs. 5, 6. A locule-cast with remains of the endocarp. *Reid & Chandler Coll.*, Minster, 1929.

Section V. *TINOSPOREAE* Diels

Genus TINOSPORA Miers

1851. Ann. Mag. Nat. Hist., (2), vii, p. 38.

Tinospora excavata n. sp.

Plate IV, figs. 7–10; text-figs. 3, 4.

Diagnosis.—Endocarp smooth externally, with an inconspicuous median ridge and large, deep ventral hollow. Length of locule-cast, 5·2 to 7 mm.; breadth, 4·3 to 6 mm.; depth, 3·3 to 5 mm. Length of ventral hollow when endocarp is preserved, 1·5 mm.; breadth, 1 mm.

Holotype.—V. 22163.

Description.—*Endocarp:* Hemispherical or gibbous with an inconspicuous median dorsal ridge, deeply depressed ventrally to form a large gibbous or hemispherical hollow from one and a half to three times as deep as the thickness of the locule; bisymmetric about the median dorsi-ventral plane; smooth externally (Pl. IV, figs. 7–9; text-figs. 3, 4). Walls woody, somewhat fluted around the

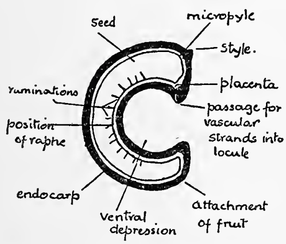


Fig. 3.—Diagrammatic longitudinal section through an endocarp of *Tinospora excavata*.

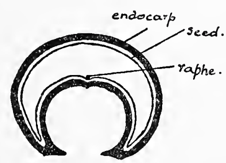


Fig. 4.—Diagrammatic transverse section across an endocarp of *Tinospora excavata*.

ventral hollow, about 0·1 mm. thick, formed of coarse, criss-cross fibres, the inner layer, which constitutes the locule-lining, being formed of similar but much finer fibres. Placenta sub-apical on the ventral face, just within the ventral hollow (text-fig. 3). Locule similar in shape to the endocarp. Length of locule-cast, 5·2 to 7 mm.; breadth, 4·3 to 6 mm.; depth, 3·3 to 5 mm.; length of ventral hollow in one specimen, 3·3 mm.; breadth, 3·2 mm.; depth, 2·2 mm. Length of ventral hollow in a specimen where the endocarp was preserved, 1·5 mm.; breadth, 1 mm. Length of aperture of ventral hollow in a similar specimen, 1·3 mm.; breadth, 1 mm.

Seed: Deeply cup-shaped, ruminate on the ventral (concave) side, pendulous, and anatropous with median ventral raphe (Pl. IV, fig. 10; text-figs. 3, 4); testa thin, formed of polygonal cells (about 0·05 to 0·07 mm. across) which show a tendency to become square over the main body of the seed, although around the ventral margin they are radially elongate.

The dimensions of the seed are virtually equivalent to those of the locule-cast.

REMARKS.—About forty specimens from Sheppey; one has also been found at Herne Bay. Almost all are locule-casts from which the endocarp has been largely abraded except where the pyrites filling the ventral hollow has protected the underlying wall within the concavity (Pl. IV, figs. 7–9). It is obvious that in specimens with the endocarp thus preserved, the hollow appears much smaller than it does in those from which it has decayed. A few specimens, when first collected, showed the whole of the endocarp, but it was always much cracked and fell to pieces at once. One well developed specimen showed an actual seed from which the carpel and locule-cast had both been completely worn away except in the ventral hollow (Pl. IV, fig. 10). Another seed was fractured longitudinally, and thereupon it showed ruminations along the ventral surface which, in section, appeared as conical infolds of the testa passing into thin films and penetrating into the pyrites of the seed-cast. Other fragments also showed the ruminations. Usually only the internal cast of the seed (showing the tegmen?) is preserved, but in one specimen the testa remained on the cast as a thin carbonaceous coat formed of well-defined polygonal cells.

In addition to casts of locules and seeds, casts of the ventral hollow are sometimes found; they usually bear remains of the endocarp on the surface originally in contact with the ventral wall. Further, they show on the same surface a well-marked dorsal, longitudinal groove, the cast of a ridge on the ventral wall of the carpel (Pl. IV, fig. 8). This ridge corresponds with a furrow on the inner surface of the carpel and also corresponds in position with the raphe, which produces a slight median ridge on the ventral surface of the seed (text-fig. 4).

AFFINITIES.—There can be no doubt that this fruit belongs to the section Tinosporeae Diels of the family Menispermaceae, and among the members of this section it shows the closest relationship to the genus *Tinospora*, which has the same general form, the same rounded ventral hollow in the endocarp, the rumination of the seed, and the same structure of endocarp, testa, and tegmen. The style and attachment of the fruit are terminal at opposite ends, the placenta is median and sub-apical on the ventral side, close to the style; the seed is pendulous and anatropous, with a median ventral raphe. A typical specimen of *T. sagittata* Gagnep. has length, 5·1 mm.; breadth, 5·7 mm.; depth, 3·6 mm.; length of ventral hollow, 2·2 mm.; breadth, 2 mm.; depth, 1·9 mm. It differs from the fossil in its form, which is often broader than long, also in the marked dorsal keel or ridge, and in its somewhat rugose surface. A specimen of *T. malabarica* Miers measures 7 mm. in length, 7 mm. in breadth, 5 mm. in depth, and the depth of the ventral hollow is 3 mm. The semi-ovoid endocarp is smooth. These species are so similar in their characters to the fossil that we have referred it to the living genus, giving it a specific name to indicate the great depth of the ventral hollow.

Tinospora is a genus of climbers living in China, India, the Malay Peninsula, the East Indies, North Australia, and east and west Tropical Africa.

A specimen of *T. excavata* is illustrated by Crow in his manuscript catalogue (1810, number 700).

V. 22163 Holotype, figured Pl. IV, fig. 7. A locule-cast.
V. 22164 Figured Pl. IV, fig. 9. A locule-cast. It was fractured longitudinally and then figured, to show the proportions of the plug and locule.
V. 22165 Figured Pl. IV, fig. 8. A locule-cast fractured transversely, showing the groove on the ventral wall of the locule.
V. 22166 Figured Pl. IV, fig. 10. An internal cast of a seed, exposed by the abrasion of the locule-cast. It was in a jar, with a locule-cast labelled " *Sabal* sp. nov." by Ettingshausen.
V. 22167 A pyrites cast of the ventral hollow showing the median dorsal groove.
V. 22168 A well-preserved locule-cast with little of the endocarp preserved, and without pyrites filling the ventral concavity.
V. 22169 A cast, now fractured, to show the relation between the locule and the pyrites plug filling the ventral hollow.
V. 22170 A locule-cast labelled by Ettingshausen " *Sabal* sp. nov."
V. 22171 Two locule-casts.
V. 22172 Nine locule-casts with remains of the endocarp, also numerous fragments.
V. 22173 Two seed-casts, now broken.
All the above are from the Bowerbank Coll., Sheppey.
V. 22174 Three locule-casts. *Reid & Chandler Coll.*, Minster, 1928.
V. 22175 Thirteen locule-casts. *Reid & Chandler Coll.*, Minster, 1929.
V. 22176 A locule-cast with endocarp originally complete, but cracked all over and now rapidly decaying and falling away. Fragments of the endocarp are still preserved with the specimen. *Reid & Chandler Coll.*, Minster.
V. 22177 A large locule-cast. *D. J. Jenkins Coll.*, Herne Bay, 1932.

Tinospora rugosa n. sp.

PLATE IV, figs. 11, 12.

DIAGNOSIS.—Endocarp with closely-spaced flat tubercles which form an irregular marginal ridge at the junction of the ventral and dorsal surfaces. Median dorsal ridge obscure, apex not mucronate or keeled. Ventral hollow large with a large ventral aperture. Length, 5·3 mm. ; breadth, 4·2 mm. ; depth, 3 mm.

HOLOTYPE.—V. 22178.

DESCRIPTION.—*Endocarp:* Approximately semi-ovoid, convex on the dorsal surface and deeply depressed on the ventral surface so as to form a large gibbous or hemispherical hollow. The locule is therefore deeply boat-shaped. Style terminal. External surface ornamented with numerous flat tubercles; these sometimes merge into one another to produce a few obscure lateral ridges directed obliquely from an inconspicuous irregular longitudinal ridge at the junction of the dorsal and ventral surfaces. Plane of symmetry marked on the dorsal surface by a smooth median longitudinal ridge, and within the ventral hollow by a thin sharp ridge. Walls woody, probably thin, formed of fine criss-cross fibres. Position of placenta indicated externally by a small apical prominence on the ventral face, at the margin of the ventral hollow. Seed not seen. Length of endocarp, 5·3 mm. ; breadth, 4·2 mm. ; depth, 3 mm.

REMARKS.—One fruit only, apparently a locule-cast with a film of endocarp adhering. The ventral cavity is not filled by pyrites, hence its form and the median ridge can be seen.

Affinities.—The relationship to *Tinospora* is again clear. Rugose endocarps are commoner in the living genus than smooth ones, the greater number of those which we have seen being more highly rugose than the fossil, and having a conspicuous ridge at the apex in the plane of symmetry. *T. sagittata* Gagnep. has somewhat comparable fruits with low tubercles, but these do not form a definite longitudinal ridge at the junction of the dorsal and ventral surfaces; the endocarp is semi-ovoid and is not unlike the fossil in shape. The distribution of the genus *Tinospora* is given on p. 166.

V. 22178 Holotype, figured Pl. IV, figs. 11, 12. An endocarp. *D. J. Jenkins Coll.*, Herne Bay.

Section VIII. *COCCULEAE* Diels

Sub-section *COCCULINAE* Diels

Genus EOHYPSERPA nov.

Diagnosis.—Endocarp bisymmetric, sub-annular, but limbs not meeting, inflated, style at one extremity; surface ornamented with transverse ribs which sometimes bifurcate; each limb sub-crescentic in transverse section, but with a lateral prolongation on the inner curve which forms a median plate. Locule and seed similar in shape to the endocarp. Testa thin, formed of an outer coat of polygonal cells and an inner one of transversely elongate cells.

Genotype.—*E. Parsonsi* n. sp.

Eohypserpa Parsonsi n. sp.

Plate IV, figs. 13–21.

Diagnosis.—That of the genus.

Holotype.—V. 22179.

Description.—*Endocarp:* General form sub-globose with its lateral faces somewhat flattened, bisymmetric about a median plane parallel with the lateral faces. Actually the carpel is curved into a ring in the plane of symmetry so that its extremities meet but do not merge (Pl. IV, figs. 13–17). The style is at the extremity of one of the limbs (Pl. IV, fig. 17). The inner wall of the curved endocarp is produced laterally to form a flattened median plate, hollow where it adjoins the locule of which it forms a continuation, but solid towards its centre, where, also, it is incomplete, being pierced by a hole (Pl. IV, fig. 18). The locule is similar in shape to the endocarp, on each lateral face of which there is a median hollow (Pl. IV, fig. 18). The hollows are truncately conical, but at the base of the endocarp they are continued as a narrow passage to the exterior between the limbs. Almost invariably these cavities are filled with pyrites. The casts so formed are therefore truncately conical, with a lateral tongue-like prolongation corresponding to the narrow passage between the endocarp limbs (Pl. IV, figs. 19, 20). When the plugs are detached, the adherent cells of the endocarp are seen to radiate from the centre of the flat base of the cone (formerly in contact with the median plate) and from its apex to the margin of the base; this indicates that on the endocarp itself they diverge from the centre of the plate transversely over the surface of the carpel. The endocarp wall is transversely ribbed on its outer surface (Pl. IV, figs. 13, 14), but owing to abrasion, the smooth locule-cast is often exposed (Pl. IV, figs. 14–16). It is thick and formed of fibres which are variously aligned, the innermost layer being transverse so that the locule-lining appears, in the main, to be transversely striate. But this simple arrangement of striae is to some extent confused by the superimposed impressions or adherent remains of the other layers of fibres, so that a criss-cross effect is often produced. Diameter of endocarp in plane of symmetry, 6 to 10 mm.; thickness at right angles to plane of symmetry, 4·65 to 9 mm.

Seed: The seed conforms to the locule in shape except that it does not pass into the lateral extension within the median plate (Pl. IV, figs. 18, 21). Testa thin and delicate, formed externally of minute polygonal cells, about 0·01 mm. in diameter, which give a finely pitted surface; the seed-cavity is lined with a delicate layer of thin-walled cells (0·01 to 0·02 mm. in their shorter diameter), which are elongate transversely and give rise to delicate transverse striations over the outer curve of the seed, but over the inner curve appear to be irregularly arranged, so far as they have been seen.

Remarks.—Sixteen specimens. The majority are so abraded that little of the endocarp remains, and the casts of the locules and of the lateral cavities are alone preserved. In one or two instances a portion of the locule-cast has broken away, showing, embedded within it, the internal cast of the seed with remains of the testa still adhering (Pl. IV, fig. 15).

Affinities.—Endocarps having the form and structure of the fossil are found in the family Menispermaceae, and particularly in *Hypserpa* Miers, a genus belonging to the tribe Cocculeae and sub-tribe Cocculinae of Diels, which occurs in Indo-Malaya. We thought at first that the fossil should be included in this genus, but a more critical examination, and the discovery by ourselves of better preserved specimens on the foreshore at Sheppey, showed that there were characters in the fossil which forbade its inclusion. In the first place, in all living species, the fruit is much compressed laterally, whereas in the fossil it is usually (when undistorted) much inflated, and its diameter at right angles to the plane of symmetry may be equal to, or greater than, the diameter in that plane. In the second place, the curvature of the carpel is more symmetric than in *Hypserpa*. In the third place, the transverse section of the locule is more elongate but more sharply curved at the cusps than in the living genus, and the lateral cavities are relatively larger. In the fourth place, the sculpture of the two is dissimilar. In the fossil there is a thick rim round the apertures of the lateral cavities from which the transverse ribbing is given off. The ribs are comparatively fine and even, and scarcely prominent, and they only divide into more or less parallel branches towards the median marginal line; also they anastomose but rarely. Consequently the surface is not tubercled or angular. The endocarps of *Hypserpa*, on the other hand, are not ribbed, but a strong ridge passes around the apertures of the lateral cavities, and from this, oblique branches are given off which anastomose over the surface, forming a very coarse network of sharp, angular ridges.

Although in other respects less like the fossil, *Cocculus* more resembles it in its ribbing than does *Hypserpa*. But in *Cocculus* the ribs are more regularly transverse, they do not branch or anastomose, and are much more angular and conspicuous. The endocarps are also much smaller, more narrowly crescentic in section, and more uniformly curved so that the lateral cavities, although large, are more truncate with less sloping sides and wider openings to the exterior.

The endocarps of *Limacia* Lour. are also somewhat similar, but in these the two lateral cavities are relatively much larger, the locule being proportionately smaller and more triangular in transverse section than in the fossil. On the whole they show a less close resemblance to the fossil than do the endocarps of *Hypserpa*.

Since the Sheppey fruit differs in the respects described above from all allied genera, we have given it the new generic name *Eohypserpa*, and the specific name *Parsonsi* after James Parsons, who figured it in 1757 (pl. xvi, fig. 6) under the name "millipede or woodlouse." Crow also, in his manuscript catalogue, gives an illustration of an endocarp (1810, number 658).

V. 22179 Holotype, figured Pl. VI, fig. 13. An endocarp with ribbed external surface preserved. *Reid & Chandler Coll.*, Minster, 1928.

V. 22180 Figured Pl. IV, fig. 16. A locule-cast now fractured to show the structure. *Bowerbank Coll.*, Sheppey.

V. 22181 Figured Pl. IV, fig. 17. A small locule-cast, figured to show the base. *Bowerbank Coll.*, Sheppey.

V. 22182 Figured Pl. IV, fig. 15. A locule-cast which has been chipped away at the extremities of the curved limbs to show the cast of the seed lying within. *Bowerbank Coll.*, Sheppey.

V. 22183 The remains of a locule-cast, and the pyritized casts which filled its lateral cavities. Figured to show the isolated casts of the lateral cavities, Pl. IV, figs. 19, 20. *Bowerbank Coll.*, Sheppey.

V. 22184 Figured Pl. VI, fig. 18. A locule-cast, fractured and figured to show the transverse section. *Reid & Chandler Coll.*, Minster, 1928.

V. 22185 Figured Pl. IV, fig. 21. Seed with fragments of locule-cast, some detached, some still adhering to it. *Reid & Chandler Coll.*, Minster, 1928.

V. 22186 Figured Pl. IV, fig. 14. An endocarp with part of the ribbed carpel wall preserved, part broken away to expose the relationship of the wall to the unribbed locule-cast. *Reid & Chandler Coll.*, Minster, 1928.

V. 22187 An abnormally broad locule-cast with remains of carpel wall. *Reid & Chandler Coll.*, Minster, 1928.

V. 22188 Four locule-casts intact, and a fifth now broken in pieces. *Reid & Chandler Coll.*, Minster, 1929.

V. 22189 Two locule-casts, one with much of the carpel wall remaining. *Bowerbank Coll.*, Sheppey.

Family MAGNOLIACEAE

In the London Clay of Sheppey seeds occur which can only be referred to the family Magnoliaceae. Among the living members of the family comparable seeds are found in three genera *Magnolia* Linn., *Michelia* Linn., and *Mangletia* Blume. We therefore made as complete and detailed comparison of these genera as was possible. We have found that, as a rule, *Michelia* and *Mangletia* have smaller seeds than *Magnolia*, with less marked bisymmetry, and with thinner testas; the testa being also more rugose internally and externally. The Sheppey seeds agree in character with *Magnolia* rather than with the other two genera.

Genus MAGNOLIA Linnaeus

1737. Gen., ed. 1, p. 56.

The seeds of living species of *Magnolia* are in outline either obovate, cordate, or reniform, sometimes very broadly reniform so that the length may be less than half the breadth (cf. Pl. IV, fig. 23). The micropyle and hilum are at the narrow end, the raphe is median on one of the broad faces, and the chalaza is median, or sub-median at the broad end. In living species the face which carries the raphe may be either inflated, or medianly depressed, or more or less deeply grooved. When depressed the raphe lies either in the groove or depression; when inflated, in the corresponding position. The opposite face in all species is more or less inflated and uniformly rounded, or it may be angled. Typically the seeds of *Magnolia* are bisymmetric about a median plane (in which the raphe lies) at right angles to the broad faces, but by mutual pressure of the two seeds in the pod they are frequently contracted and faceted along one side so as to be asymmetric (cf. the right hand side of Pl. V, fig. 3). Sometimes this asymmetry may be very conspicuous and the breadth is greatly contracted. Very rarely there appears to be contraction on both sides of the seed due to pressure among the crowded pods. The same cause results in a considerable variation in size and form among the individuals of one species.

The testa in *Magnolia* is formed of two very distinct coats. The outer is tough and soft; the inner is hard and woody, formed of closely compacted parenchyma, the equiaxial cells being arranged in radial rows which give to the coat a punctate surface, and a columnar appearance in radial sections. In some species (*e.g. M. Lennei* Van Houtte) the seed-cavity is lined by a thin layer of elongate cells aligned longitudinally; the fine striations so formed converge at one end of the seed to the micropyle, at the other to the chalaza. The tegmen is several cells thick. Its inner and outer surfaces are formed of thin-walled, flat, elongate cells (frequently about 0·016 mm. in diameter), usually arranged in groups of several parallel cells; these cells are aligned longitudinally and give rise to striations which converge to the micropyle and chalaza. Between the two striate surfaces is a layer of large polygonal cells varying in diameter from about 0·025 to 0·05 mm. The chalaza is marked on the hard testa by a median oval marginal scar at the broad emarginate or flattened end. The scar varies greatly in size and conspicuousness in different species. It is pierced at its centre by a broad passage for the raphe, here greatly thickened. Around this the testa is also greatly thickened so as to show, in longitudinal sections of the seed, as a marked and characteristic "collar," which is a generic character. The chalazal thickening of the raphe forms a plug which in fossilization frequently comes away, leaving a gaping aperture. Internally the chalazal scar is also oval, but is much larger and has a roughened surface. The micropyle at the opposite end of the seed is a funnel-shaped aperture narrowing towards the exterior.

The seeds of living species can approximately be divided into three groups: those which are longer than broad, a type which includes most American species; those which are as long as broad, a type including both American and East Asian species; those which are broader than long, a type to which most East Asian species belong. But it must be noted that in consequence of the distortion by mutual pressure one type may to some extent simulate another, and therefore the degree of asymmetry, when this can be estimated, must be taken into account. Further distinctions are, that in American species the chalazal scar is commonly sunk, and surrounded by a little upstanding wall of testa forming a slight rim, which we have not seen in Asiatic species. Also in American species the hard testa is often more or less corrugated longitudinally, whereas in Asiatic species it is, as a rule, very smooth with gently undulating contours. This distinction is very generally persistent.

In fossilization we have never yet found the outer tough coat of the testa preserved. The seeds are always represented by the hard woody coat. The cell structure of this coat, the general form, and, in especial, the remarkable structures associated with the chalaza, make the seeds of *Magnolia* readily recognizable. Yet differences in abrasion result in very different appearances. Thus the difference between seeds with the testa wholly preserved, those in which it is sufficiently abraded to show the curious structure of the collar, and those in which it is altogether wanting, so that only the seed-cast with the impression of the internal chalaza remains, are very great.

It will be recognized from the above discussion of the form and characters of living seeds, and the results of abrasion on the fossil seeds, that the discrimination of one species from another is not an easy task in every instance. But, taking account of all the available evidence, it appears to us possible to classify the London Clay magnolias into the following species: *M. longissima* (Bowerb.), *M. lobata* (Bowerb.), *M. subquadrangularis* (Bowerb.), *M. crassa* n. sp., *M. subtriangularis* n. sp., *M. angusta* n. sp., *M. subcircularis* n. sp. We have also retained as a distinct species *M. enormis* (Bowerb.), which we have not seen, basing our determination on Bowerbank's figures and descriptions.

A study of Bowerbank's genus *Leguminosites* (1840, pp. 124–140, pl. xvii, figs. 1–41) leaves no doubt that most, but not all of his species, are seeds of *Magnolia*; and that they cannot be referred to the family Leguminosae as he supposed. But although his study of the specimens led him to a wrong determination, his descriptions are good, and Sowerby's figures are admirable. Consequently we have been able to recognize some of his type specimens even when they have suffered partial change through the decay of years, such as the breakage at one end of the specimen represented in his pl. xvii, figs. 10, 11 (cf. Pl. IV, figs. 22, 23).

His division into species is based largely on variety of form, but he also describes differences in the "hilum" (chalaza: he mistook the peculiar thickening of the testa at the chalazal scar for the radicle). It is true that in general the form is all there is to rely upon in discriminating between one species and another, for such characters as thickness of testa or size of cells may recur in more than one species. Nevertheless, some of the differences in form which he thought were specific are probably individual, such as may occur in living species, or may be produced in fossil species by abrasion.

The specimens of *Magnolia* described below belong, in the main, to the Bowerbank Collection, but a few were found by ourselves at Sheppey in 1928 and 1929. Bowerbank's seeds were in three jars labelled respectively, by Ettingshausen, "*Leguminosites* Bowerbank" [correctly], "*Apeibopsis variabilis* Bowerb.", and "*Sapotacites* sp. 1." Those labelled *Apeibopsis* were of the narrow, longer-than-broad type (see *M. angusta*, p. 177), and were evidently mistaken by Ettingshausen for the ovoid seeds (p. 406) of *Oncoba variabilis* (Bowerb.), which they in no way resemble except in their general form.

In 1879 (p. 394) Ettingshausen also listed two genera of the family Magnoliaceae, *Magnolia eocenica* and *Illicium Apollinis*. As we have seen no specimens, and as there are no figures or descriptions, we cannot form any opinion as to the affinities of these fossils, nor as to their relationship to the seeds described below.

Magnolia longissima (Bowerbank)

PLATE IV, figs. 22–24.

1840. *Leguminosites longissimus* Bowerbank, p. 128, pl. xvii, figs. 10, 11.
1840. *? Leguminosites gracilis* Bowerbank, p. 129, pl. xvii, figs. 12, 13.
1879. *Leguminosites longissimus* Bowerbank: Ettingshausen, p. 396.
1879. *? Leguminosites gracilis* Bowerbank: Ettingshausen, p. 396.

DIAGNOSIS.—Seed very broadly reniform, more than twice as broad as long, compressed, with a broad shallow median longitudinal depression on one face; length, 6·25 mm.; breadth, 16 mm.; maximum thickness of testa (as preserved), 0·7 mm.

HOLOTYPE.—V. 22190.

DESCRIPTION.—*Seed:* Very broadly reniform in outline, much broader than long, compressed from side to side, with a broad shallow median longitudinal depression on one face. Testa thick, formed of equiaxial polygonal cells with thickened lateral walls which give a pitted inner surface to the testa and in radial sections of the seed are seen to be arranged in a columnar manner (Pl. IV, fig. 24); the cells are about 0·106 mm. in diameter. The lining coat of the testa has not been clearly seen. The tegmen is formed of delicate elongate thin-walled cells (about 0·016 mm. in breadth) which are aligned longitudinally so that the surface is striate from base to apex, *i.e.* from micropyle to chalaza. Internal scar of the chalaza large, elongate-oval. Length, 6·25 mm.; breadth (incomplete), 13·5 mm., 16 mm. when complete, according to Bowerbank's figures; thickness, 4·25 mm.; maximum thickness of testa (as preserved), about 0·7 mm.

REMARKS.—One specimen, broken obliquely across its breadth before it came into our hands. Thanks to the excellence of J. de C. Sowerby's illustrations, it can still be recognized as the type of Bowerbank's *Leguminosites longissimus*. In his description Bowerbank indicates the remains of the testa by the letters *d, d, d;* but the surface beneath these fragments of testa is not, as he thought, that of the cotyledons but of the internal cast of the seed. In the oblique fracture the infilling of pyrites between testa and tegmen can be seen, also the pyrites within the tegmen which replaces the decayed albumen. In Bowerbank's fig. 10 the small mucro marked "*c*," and in fig. 11 the small median circular scar, indicate the cast of the micropyle.

AFFINITIES.—The form of the seed, the position of micropyle and chalaza, the character of the chalaza, the structure of the woody testa with its finely pitted internal surface and its columnar arrangement of cells, and the finely striate surface of the tegmen, are all characteristic of *Magnolia.* We have therefore no hesitation in assigning the fossil to that genus. The broad oval form of seed is most commonly found in Chinese and East Asian species. Among the living species which we have seen, the seeds which most resemble it are those of *M. nitida* W. W. Smith, from Yunnan. The specimen broadest in proportion to its length (7 mm.) measured 16 mm.

The specimen figured as *Leguminosites gracilis* by Bowerbank (1840, pl. xvii, figs. 12, 13) may also have belonged to *M. longissima,* with which it agrees in size and general contour, differing only in its relatively greater length and in the greater degree of compression, as shown by a comparison of Bowerbank's figs. 11 and 12.

V. 22190 Holotype, figured Pl. IV, figs. 22–24. Also figured Bowerbank (1840), pl. xvii, figs. 10, 11, as *Leguminosites longissimus.* An internal cast of a seed with remains of the testa. The tegmen is also shown, but it is crumpled. *Bowerbank Coll.,* Sheppey.

Magnolia lobata (Bowerbank)

PLATE IV, figs. 25–27.

1840. *Leguminosites lobatus* Bowerbank, p. 133, pl. xvii, figs. 23–25.
1840. *Leguminosites dimidiatus* Bowerbank, p. 130, pl. xvii, figs. 16–18.
1840. *Leguminosites inconstans* Bowerbank, p. 134, pl. xvii, figs. 26–28.
1840. *Leguminosites reniformis* Bowerbank, p. 135, pl. xvii, figs. 29, 30.
1840. *Leguminosites aequilateralis* Bowerbank, p. 137, pl. xvii, figs. 35–37.
1879. *Leguminosites lobatus* Bowerbank: Ettingshausen, p. 396.
1879. *Leguminosites dimidiatus* Bowerbank: Ettingshausen, p. 396.
1879. *Leguminosites inconstans* Bowerbank: Ettingshausen, p. 396.
1879. *Leguminosites reniformis* Bowerbank: Ettingshausen, p. 396.
1879. *Leguminosites aequilateralis* Bowerbank: Ettingshausen, p. 396.

DIAGNOSIS.—Seed broader than long, somewhat compressed, with a broad median longitudinal depression on one face; from 3·6 to 6 mm. long, 5·5 to 8 mm. broad, and 2·4 to 3 mm. thick.

NEOTYPE.—V. 22191.

DESCRIPTION.—*Seed:* Rather broader than long, sub-reniform, slightly compressed, and hollowed on one face so as to be somewhat saddle-shaped (Pl. IV, fig. 25). Hilum, chalaza, testa, and tegmen as in the genus (see p. 171). Testa much abraded, original thickness not seen, columnar cells about 0·012 to 0·016 mm. broad. Lining of testa formed of elongate cells, also from 0·012 to 0·016 mm. broad in the majority of specimens, although on a few seed-casts these cells are broader, 0·016 to 0·025 mm. Elongate cells of tegmen 0·016 mm. broad, frequently about 0·1 mm. long; polygonal cells of the same, 0·025 mm. in diameter. The measurements of typical specimens are: (1) Length, 6 mm.; breadth, 6·3 mm.; thickness, 2·7 mm. (2) Length, 5 mm.; breadth, 8 mm.; thickness, 2·7 mm.

(3) Length, 5 mm.; breadth, 7 mm.; thickness, 3 mm. (4) Length, 3·6 mm.; breadth, 5·5 mm.; thickness, 2·4 mm.

REMARKS.—More than a dozen specimens. These lobed seeds vary somewhat in size and form, but not more so than the seeds of a living species. The figures in Bowerbank's monograph suggest that five of the supposed species of *Leguminosites* (1840, pl. xvii, figs. 16–18, 23–30, 35–37) belong to the species we are now discussing. Among the extant specimens of the Bowerbank Collection, we were only able to recognize the type of one of these five species—that of *L. reniformis*. But this seed is by no means typical of, although apparently it belongs to, the species under discussion; it is therefore inappropriate to make it the holotype of the redefined species. Hence we have adopted the name *M. lobata* (Bowerbank), from among the five possible synonyms, to designate this species because, as the illustrations show, the seed so named is typical, while the name itself is quite appropriate.

AFFINITIES.—The relationship of this species to *Magnolia* is indisputable. *M. parviflora* Sieb. & Zucc., a Chinese species, is extremely close to the fossil in its characters. It is almost identical with it in size and form, but the columnar cells of the testa are only 0·025 mm. in diameter. Another distinction is that the lining of the testa is formed of polygonal cells arranged in longitudinal rows, not of narrow elongate cells as in *M. lobata*.

V. 22191 Figured Pl. IV, figs. 25–27. An internal cast of a seed.
V. 22192 Internal cast of seed figured by Bowerbank (1840, pl. xvii, figs. 29, 30) as *Leguminosites reniformis*.
V. 22193 Eight specimens, internal casts of seed with remains of testa adhering, some fractured to show the cast of the tegmen.
V. 22194 Two worn seeds. *Reid & Chandler Coll.*, Minster, 1929.
V. 22195 A seed now fallen in pieces so that it shows the cast of the tegmen.
V. 22196 Ten seeds and fragments of seeds which probably belong to *M. lobata*.

Numbers V. 22191–93, –95, and –96 were all in a jar labelled "*Leguminosites* Bowerbank" by Ettingshausen.

All but V. 22194 *are from the Bowerbank Coll.*, Sheppey.

Magnolia subquadrangularis (Bowerbank)

PLATE IV, figs. 28, 29.

1840. *Leguminosites subquadrangularis* Bowerbank, p. 137, pl. xvii, figs. 33, 34.
1879. *Leguminosites subquadrangularis* Bowerbank: Ettingshausen, p. 396.

DIAGNOSIS.—Seed sub-quadrangular, broader than long, very slightly hollowed near the chalaza on the raphe side, chalazal margin straight, micropylar end rounded; length from 5·2 to 5·5 mm., breadth from 7 to 7·5 mm., thickness 2·8 to 4·6 mm.

HOLOTYPE.—V. 22197.

DESCRIPTION.—*Seed:* Sub-quadrangular, straight on the chalazal margin, convex on the micropylar margin, broader than long, thick, very slightly hollowed or flattened close to the chalaza but otherwise convex on the face which bears the raphe, as well as on the opposite face. Micropyle, chalaza, testa, and tegmen as in the genus. Columnar cells of testa 0·016 mm. in diameter, lining of testa formed of elongate cells about 0·03 mm. broad. Elongate cells of tegmen about 0·012 mm. broad. Polygonal cells of tegmen from 0·025 to 0·05 mm. in diameter. Length of most perfect specimen, 5·5 mm. ; breadth, 7·5 mm. ; thickness, 4·6 mm. ; maximum thickness of testa (as preserved), 0·4 mm. Length of holotype, 5·2 mm. ; breadth, 7 mm. ; thickness, 2·8 mm.

REMARKS.—The description given above is based on the best preserved of two specimens. The less well-preserved seed is still quite recognizable as the type of *Leguminosites subquadrangularis* Bowerbank. In this specimen, although the thick testa is worn and chipped, it is possible to trace the columnar arrangement of the small parenchymatous cells which form it, and to see very clearly the characteristic chalazal scar and, in parts, the coats of the tegmen, both the coat of polygonal cells and that formed of elongate cells.

AFFINITIES.—The specimens are undoubtedly magnolias and the species is rather clearly marked off from the other fossil species described. It perhaps comes closest to *M. lobata*, from which it differs chiefly in the convexity of the raphe-bearing surface, in the straight chalazal margin, and in its slightly lesser proportional breadth.

V. 22197 Holotype, a seed, figured by Bowerbank (1840, pl. xvii, figs. 33, 34) as *Leguminosites subquadrangularis*, now much decayed and somewhat broken. *Bowerbank Coll.*, Sheppey.

V. 22198 Figured Pl. IV, figs. 28, 29. A well-preserved seed with part of the testa chipped away. *Bowerbank Coll.*, Sheppey.

Magnolia crassa n. sp.

PLATE V, figs. 1, 2.

1879 ? *Sapotacites Mimusops* Ettingshausen (pars), p. 394.

DIAGNOSIS.—Seed asymmetrically obovate in outline, truncate at the chalazal end and blunt at the hilar end, convex or roundly angled on the face carrying the raphe, less convex on the opposite face, longer than broad, chalazal scar small; length, 8 mm. ; breadth, 6·8 mm. ; thickness, 3·5 mm.

HOLOTYPE.—V. 22199.

DESCRIPTION.—*Seed:* Asymmetrically obovate in outline, truncate at the chalazal end and blunt at the hilar end, convex or roundly angled on the side which carries the raphe, less convex on the opposite side, longer than broad ; chalaza, testa, and tegmen as in the genus, chalazal scar rather small ; columnar cells of testa, 0·016 mm. in diameter, lining of testa formed of elongate cells, 0·025 mm. broad ; elongate cells of tegmen, about 0·016 mm. broad ; polygonal cells of tegmen, about 0·025 mm. in diameter. Length of seed (worn at micropylar end), 7·5 mm. ; breadth, 6·5 mm. ; thickness, 3·5 mm. A second more doubtful specimen measured, length, 8 mm. ; breadth, 6·8 mm. ; thickness (much worn, testa entirely removed on one side), 2·8 mm.

AFFINITIES.—We have taken as the type of this species a specimen labelled by Ettingshausen " *Sapotacites* sp. 1." It shows every character of the genus *Magnolia*, and none of the family Sapotaceae. There can be no doubt as to its true relationship. A second specimen, not so thick and of more regular and elongate form, we have referred very doubtfully to this species.

The seed of this species closely resembles that of *M. angusta* in form. Its length is the same as that of the largest specimens of *M. angusta*, but it is considerably thicker, broader, and blunter at the hilar end, also the angle of the face carrying the raphe is more obtuse and more rounded. These differences are possibly not specific, for in view of the individual differences which may occur in any one living species, it is sometimes difficult, among fossil forms, to distinguish between individual and specific differences.

V. 22199 Holotype, figured Pl. V, figs. 1, 2. Internal cast of seed with remains of testa. Labelled by Ettingshausen "*Sapotacites* sp. 1." *Bowerbank Coll.*, Sheppey.

V. 22200 A second seed with remains of testa, possibly belonging to this species. It was in a jar with other species labelled "*Leguminosites* Bowerbank" by Ettingshausen. *Bowerbank Coll.*, Sheppey.

Magnolia subtriangularis n. sp.

Plate V, figs. 3–5.

Diagnosis.—Seed roundly sub-triangular, nearly straight on the chalazal margin, rounded at the micropyle, broader than long, with a broad median longitudinal hollow on one face ; length, 6·5 mm. ; breadth, 8 mm.

Holotype.—V. 22201.

Description.—*Seed :* Roundly sub-triangular, more or less straight along the chalazal margin and pointed at the micropylar end, slightly broader than long, slightly convex on one face, grooved or saddle-shaped on the other ; micropyle, chalaza, and testa as in the genus, chalazal scar large and broad ; full thickness of the testa not seen owing to abrasion. Columnar coat of the testa formed of cells 0·025 to 0·03 mm. in diameter, and the lining of elongate cells 0·016 to 0·025 mm. broad ; cells of tegmen not clearly seen. Length of seed (broken specimen), 6·5 mm. ; breadth, 7·5 mm. Length of seed (angled on one face as the result of mutual pressure), 6·5 mm. ; breadth, 8 mm.

Remarks.—Two specimens ; one collected by ourselves at Minster is much abraded and polished and shows little beyond the general shape. The other, from the Bowerbank Collection, is broken on one side at the micropylar end, but its form is still apparent. It shows the lining of the testa clearly, and over the chalaza some of the actual cells of the testa are still preserved. Immediately around the chalaza, within the cast of the testa the cells of the tegmen can be seen, but they are somewhat shrivelled and contracted.

Affinities.—The specimens show the usual characters of *Magnolia* seeds. They are distinguished from all other London Clay species by their triangular form and their relative proportions.

V. 22201. Holotype, figured Pl. V, figs. 4, 5. An internal cast of a seed, broken at one side near the base. Labelled by Ettingshausen, with other *Magnolia* seeds, "*Leguminosites.*" *Bowerbank Coll.*, Sheppey.

V. 22202. Figured Pl. V, fig. 3. A worn and polished seed. *Reid & Chandler Coll.*, Minster, 1929.

Magnolia angusta n. sp.

Plate V, figs. 6–8.

1840. *? Leguminosites cordatus* Bowerbank, p. 139, pl. xvii, figs. 40, 41.
1879. *? Leguminosites cordatus* Bowerbank : Ettingshausen, p. 396.
1879. *Apeibopsis variabilis* (Bowerbank) : Ettingshausen (pars), p. 395.

Diagnosis.—Seed roundly triangular or obovate, longer than broad, convex or angled on both faces, somewhat pointed at the micropyle ; length, 6·6 to 8 mm. ; breadth, 3·5 to 5 mm. ; thickness, 3 mm.

HOLOTYPE.—V. 22203.

DESCRIPTION.—*Seed:* Roundly sub-triangular, narrow, and longer than broad, relatively little compressed, gently convex on the face which carries the raphe, bluntly angled on the opposite face. Chalaza, micropyle, testa, and tegmen, as in the genus ; testa about 0·5 mm. thick (as preserved) in the thickest part ; columnar cells of testa about 0·016 mm. broad, and the individual cells which make up the columns about 0·03 mm. deep ; lining layer of the testa formed of elongate cells, 0·012 mm. broad ; elongate cells of tegmen, 0·012 mm. broad ; polygonal cells of tegmen, 0·03 to 0·05 mm. in diameter. The seeds of this species are frequently asymmetric and faceted owing to mutual pressure during growth. Length of seed from 6·6 to 8 mm. ; breadth, 3·5 to 5 mm. ; thickness about 3 mm. ; maximum thickness of testa about 0·35 mm. as preserved.

REMARKS.—Several seeds fairly well preserved. Three were in a jar labelled "*Leguminosites* Bowerb." by Ettingshausen ; but he had labelled the majority "*Apeibopsis variabilis* Bowerb." Nevertheless, we have seen no types of any of Bowerbank's various species of *Leguminosites*. Four seeds were found by ourselves at Sheppey.

AFFINITIES.—The specimens described resemble those living magnolias with seeds of the longer-than-broad type, having the raphe-bearing face rounded, and a testa which is not very thick. Living magnolias of this type are of American distribution, and *M. grandiflora* Linn. and *M. glauca* Linn. may be taken as characteristic species. In both these species the testa is hard and thin. The fossil seeds are almost identical in size and shape with the seeds of *M. grandiflora*, but those of *M. glauca* are rather smaller. We also made comparison with *Michelia* seeds. Two of the fossils resembled them in general form, but the other specimens did not, and as there is no reason for separating these two from the others, the superficial resemblance cannot be regarded as implying generic relationship to *Michelia*. In this genus the testa is either thick or very thin, the excavation at the chalaza is very shallow and usually narrow, not broad and deep as in *Magnolia*. The tegmen is composed in some species of coarser, or in others of finer cells.

It is possible that *Leguminosites cordatus* Bowerbank (1840, p. 139, pl. xvii, figs. 40, 41) may belong to this species, but it is appreciably broader and flatter than the typical specimens. As the type is no longer extant, its relationship must remain uncertain.

V. 22203 Holotype, figured Pl. V, figs. 6–8. A seed with the testa partly preserved. Labelled "*Leguminosites* Bowerb." by Ettingshausen.

V. 22204 An internal cast of the testa, showing the distortion due to mutual pressure of seeds during growth. Labelled "*Apeibopsis variabilis* Bowerb." by Ettingshausen.

V. 22205 Four seeds in various stages of abrasion. Labelled "*Apeibopsis variabilis* Bowerb." One specimen shows beautifully the micropylar canal piercing the testa.

V. 22206 A seed with testa partially preserved. It shows the chalaza and a small portion of the internal cast of the tegmen at the broad end. Labelled "*Leguminosites*."

V. 22207 A seed with the testa preserved immediately around the chalaza. It shows also the internal cast of the testa, and of the tegmen. The coarse polygonal tegmen cells are preserved in patches. Labelled "*Leguminosites*."

V. 22208 Five *Magnolia* seeds, much abraded and partly broken, which probably belong to *Magnolia angusta*. Labelled " *Apeibopsis variabilis*."

V. 22209 Two poorly preserved *Magnolia* seeds, which may be *M. angusta*.
All the above are from the Bowerbank Coll., Sheppey.

V. 22210 A seed of *Magnolia angusta* with much of the testa preserved. It shows the foramen for the raphe piercing the chalazal plug. *Reid & Chandler Coll.*, Sheppey, 1928.

V. 22211 Three well-preserved seeds in various stages of abrasion. *Reid & Chandler Coll.*, Minster, 1929.

Magnolia angusta (?)

Plate V, figs. 9, 10.

Description.—*Seed:* Roundly truncate at the chalazal end (broken at the micropylar end). Chalaza oval, with a very definite margin from which fine elongate cells, about 0·12 mm. broad, diverge over the surface of the tegmen. Outside the striate coat formed by these cells is one formed of delicate polygonal cells with well-defined lateral walls; these cells (about 0·025 to 0·075 mm. in diameter) appear in parts to be aligned in longitudinal rows, whilst in other parts they are arranged more irregularly; the testa is missing. In transverse section the seed is slightly convex on one side, and highly convex on the other, although on the more convex side the symmetry is lost as the result of faceting caused by the pressure during growth of the adjoining seed in the pod. Length of seed incomplete but probably about 5·5 mm.; greatest breadth, 5 mm.; thickness, 3 mm.

Affinities.—One imperfect specimen is the internal cast in calcite of the chalazal end of a seed to which fragments of the tegmen adhere. The form of this fragment, with the faceting of the convex side, so characteristic of *Magnolia*, and the equally characteristic oval scar of the chalaza and coats of the tegmen indicate beyond a doubt that the seed must be referred to that genus. The fragment is too incomplete to permit of definite determination, but so far as can be ascertained, it much resembles in size and form *M. angusta*; and it quite possibly belongs to that species. The seed was collected by Mr. H. A. Toombs in the Basement Beds of the London Clay at Harefield, Middlesex.

V. 22212 Figured Pl. V, figs. 9, 10. A broken seed of *Magnolia*; cast of tegmen showing chalaza. *H. A. Toombs Coll.*, London Clay Basement Beds, Harefield, Middlesex.

Magnolia subcircularis n. sp.

Plate V, figs. 11, 12.

1840. *? Leguminosites curtus* Bowerbank, p. 136, pl. xvii, figs. 31, 32.
1879. *? Leguminosites curtus* Bowerbank: Ettingshausen, p. 396.

Diagnosis.—Seed rounded, compressed, about as broad as long, chalazal scar very small, micropylar end rounded, slightly convex on both faces except for a shallow depression near the chalaza on the raphe side; length, 5 to 6 mm.; breadth, 5·2 to 6 mm.; thickness, 2 to 2·5 mm.

Holotype.—V. 22213.

Description.—*Seed:* Sub-circular, about as broad as long, much compressed; surface bearing the raphe very slightly hollowed near the chalaza, slightly convex elsewhere. Micropyle, chalaza, testa, and tegmen with the usual characters of the genus *Magnolia*, but the testa is apparently very thin (about 0·15 mm.) and the chalaza is small for so broad a seed. Columnar cells of testa, 0·016 to 0·025 mm. broad; elongate cells which line the testa, 0·016 mm. broad. Elongate cells of tegmen, 0·016 mm. broad. Length of seed, 5 to 6 mm.; breadth, 5·2 to 6 mm.; thickness, 2 to 2·5 mm.; thickness of testa as preserved about 0·15 mm.

REMARKS.—Four specimens in various states of abrasion. Three of them show that the testa was relatively thin. The fourth, found by ourselves at Minster, shows the internal cast of the testa and of the tegmen.

AFFINITIES.—The general form, as well as the characters of micropyle, chalaza, testa, and tegmen indicate that without a doubt this species belongs to *Magnolia*. Its sub-circular outline is distinctive and serves to differentiate it from other London Clay species of the genus.

It is possible that *Leguminosites curtus* Bowerbank (1840, p. 136, pl. xvii, figs. 31, 32) belongs to this species. It is certainly a *Magnolia*. Bowerbank states that the testa was mostly worn away, and that although a considerable portion of the "nucleus" [cast of tegmen] had been eaten away by "some mandibulated insect," in parts the cellular structure was preserved in a "most perfect and beautiful manner," but he does not describe the cells either of the testa or of the tegmen.

V. 22213 Holotype, figured Pl. V, figs. 11, 12. A seed with testa partially abraded so as to show the internal cast. *Bowerbank Coll.*, Sheppey.

V. 22214 A seed with much of the testa preserved, although it is battered and broken. Also a second seed with less of the testa preserved, showing the internal cast of the tegmen. *Bowerbank Coll.*, Sheppey.

V. 22215 A much abraded seed, showing the cast of testa and tegmen. *Reid & Chandler Coll.*, Minster, 1929.

Magnolia enormis (Bowerbank)

1840. *Leguminosites enormis* Bowerbank, p. 129, pl. xvii, figs. 14, 15.
1840. *? Leguminosites planus* Bowerbank, p. 132, pl. xvii, figs. 21, 22.
1840. *? Leguminosites trapeziformis* Bowerbank, p. 138, pl. xvii, figs. 38, 39.
1879. *Leguminosites enormis* Bowerbank: Ettingshausen, p. 396.
1879. *? Leguminosites planus* Bowerbank: Ettingshausen, p. 396.
1879. *? Leguminosites trapeziformis* Bowerbank: Ettingshausen, p. 396.

Bowerbank defines this species in the following terms: "Seed obscurely reniform, compressed laterally: hilum [chalaza] conspicuous, small, somewhat carunculate."

He states in the description that he possessed five specimens of the species which varied but little from one another. In two the "epidermis" [testa] was wanting and the seeds then assumed a punctate appearance. The cells of which the "testa" [tegmen] was composed were "arranged in lines which pass off in curves towards the back [micropylar end] of the seed, and are the one-thousandth part of an inch in diameter . . . The hilum [chalaza] is situated at the middle of the face of the seed; it is about the seventeenth of an inch in length, and is surrounded by a slightly-elevated fleshy ridge. The omphalodium, or part through which the nourishing vessels pass, is oval in form, and of about the fiftieth of an inch in length."

It is clear from the above description and from Bowerbank's figures that the specimens were *Magnolia*. They are not extant at the present time, and therefore it is impossible to be sure whether they represent a species distinct from any others found in the London Clay; but apparently they do. If we may judge by his figures, another of his species, *Leguminosites planus* Bowerbank, should possibly be grouped with *M. enormis*. It has no very distinctive characters, but is undoubtedly a *Magnolia*. In his description Bowerbank interprets part of the magnolian chalaza as the radicle of a leguminous seed and states that "the plumula is seen buried deeply in an excavation between the cotyledons." But his descriptions of the cotyledons in his general introduction to the genus *Leguminosites* (1840, p. 124), and our own observation of some of his actual specimens and of other specimens of *Magnolia* from the London Clay, show that he mistook for cotyledons the internal cast of the folded or crumpled tegmen, bearing on its surface the casts of the tegmen cells. Therefore, his plumule was probably merely the cast of a fold in the tegmen. *Leguminosites trapeziformis* Bowerbank, another *Magnolia*, may also belong to the species, but, again, in the absence of the type the relationship must remain uncertain.

The seeds described by Bowerbank as *Leguminosites subovatus*, *L. crassus*, *L. elegans*, *L. rotundatus*, *L. lentiformis* are not magnolias. Their affinities are discussed on pp. 503, 354, 353, 374.

Magnolia sp.

PLATE V, fig. 13.

DESCRIPTION.—*Seed:* Obovate, but with a marked tumidity pierced by a canal at the chalazal end. In longitudinal section, this tumidity is seen to form the outer wall of a small chamber lying beneath it. Testa scarcely abraded, columnar cells about 0·025 mm. broad. Lining of testa formed of elongate cells, of similar breadth, longitudinally aligned. Elongate cells of tegmen 0·016 mm. in diameter; polygonal cells about 0·05 to 0·075 mm. in diameter. Length of seed, 9·9 mm.; breadth, 6 mm.; thickness, 4 mm.; thickness of testa, 0·4 mm.

AFFINITIES.—The general similarity in form, and the aperture at the broad (chalazal) end, suggested very strongly that the one specimen was a *Magnolia* seed. Nevertheless the tumidity over the chalaza was unlike anything we had hitherto seen in that genus, and we hesitated, without support from a knowledge of its cell-structure, to refer it to the genus. We therefore fractured it. The succession and structure of the coats proved to correspond with those of the testa and tegmen in *Magnolia*, and there could therefore be no further doubt as to its relationship. It is, however, difficult to explain the presence of the chalazal tumidity and of the small chamber which was exposed within it by the fracture. Two possible explanations suggest themselves: either it is an abnormality produced by a gall, or the chalazal plug was peculiarly thick in this species, and its centre portion decayed entirely before pyritization was complete, so that a spurious chamber was formed which, later, became filled with crystalline pyrites.

V. 22216 Figured Pl. V, fig. 13. A seed, now fractured to show the structure. *Reid & Chandler Coll.* Minster, 1929.

Family ANONACEAE

Fruits referable to the family Anonaceae are very rare, but seeds occur quite commonly at Sheppey. Almost all have lost the testa either by decay prior to fossilization or as the result of later abrasion. As a rule the entity preserved is the pyrites-cast of the seed-cavity, to which a few fragments of the testa adhere, particularly in the deep slits or punctations which represent similar features in the ruminate albumen. For the casts are exact replicas of the ruminate albumen of the seed.

While the loss of the testa renders the seeds very easily recognizable as belonging to the Anonaceae, it is one of the causes which makes generic and specific determination very difficult, because the fossils can only be compared with living seeds when these also have been deprived of their testas; and it can be easily understood that material was not available for making a full study of the seeds of the family under such conditions.

The seeds of all living Anonaceae show certain characters in common when deprived of their testas, and these, in association, distinguish them from all other seeds. (1) All show bisymmetry about a plane in which lies an encircling band of fibres formed by the raphe and chalaza. This band may, or may not, be sunk in a groove (either shallow or deep) in the albumen. (2) All have ruminate albumen. The ruminations, which are similar on the two faces, may be of three types: They may be ridged transversely or radially, the ridges being more or less branched, curved, or interrupted (*e.g.* species of *Anona* Linn.); or they may be pitted (*e.g. Guettaria* Ruiz & Pav., species of *Polyalthia* Blume, *Unonopsis* R. Fries.), species of this type being rarer than those of the ridged type; or they may combine the two kinds; thus in some genera the ridges are so complicated that they produce the effect of pitting (*e.g.* species of *Polyalthia*), whilst others are pitted over the middle but ridged at the edges of the seeds. In transverse sections of the seeds the ridged albumen may show either two-partite or four-partite arrangement.

The study of living seeds of Anonaceae in Kew Herbarium led us to conclude that distinctive as are the seed characters of the family, the generic and specific characters are by no means so distinctive. The reason is that similar (possibly not identical) characters (as, for instance, ridged or punctate albumen) may occur in more than one genus, whilst different characters (for instance, again, ridged or punctate albumen) may occur in the same genus. Thus *Polyalthia* and *Anona* have ridged albumen in some species (*e.g. Polyalthia viridis* Craib), whilst other species (*e.g. P. hypoleuca* Hook. fil et Thoms.) are pitted, and *P. suberosa* Henry is pitted in the middle but ridged at the margin. It is safe to say that any marked distinction in the character of the encircling groove and raphe, or of the ruminations, indicates a difference of species, and may indicate a difference of genus. But it is not safe to say that similarity (as opposed to identity) of character necessarily implies identity of genus.

Hence, in dividing the fossils into species, we have based our determination of thirteen species on differences in essential characters, and have grouped the individuals into these species on similarities in the same characters; but we have not attempted to separate them into genera. Neither have we attempted to refer them to living genera, although in a few instances we have mentioned living genera which show a resemblance and seem to be related. In all likelihood, if a complete suite of living seeds divested of their testas had been available, we might have obtained more definite information as to the diagnosis of genera, but such a suite was not available, and we had to content ourselves with placing them in a form-genus, *Anonaspermum.* It is possible that in one or two instances we may have united more than one species, although we think this highly improbable in view of the uniformity in detailed structure shown by the individuals. It is more probable that the thirteen species described represent true species.

Even in the absence of precise information as to the affinities of the various seeds of Anonaceae, the abundance of individuals and variety of species in the London Clay is of great significance, because at the present time the family is with very few exceptions entirely tropical; *Asimina* occurs in the eastern United States and a few species in extra-tropical Australia, but otherwise they are confined to the tropics of both hemispheres, where they are very abundant.

Seeds clearly referable to Anonaceae were illustrated by Crow in his manuscript catalogue, preserved in the British Museum (1810, Nos. 477 and ? 570), also by Parsons (1757, pl. xv, fig. 9), who called them "coffee-berries." Bowerbank evidently recognized their true affinities for, although they do not occur in the only volume of his London Clay ever published, Prestwich states in a footnote (1854, p. 413) that Bowerbank had in his possession undescribed fruits and seeds, among which are enumerated two or three species of *Anana* [*Anona*]. Lyell also (1871, p. 239) mentions the occurrence of three species of *Anona* in the Sheppey flora.

Under the name *Athrotaxis* sp., Berry (1924, p. 46, pl. ii, fig. 3) described and figured a specimen from the Yegua formation (Middle Eocene) of Cross County, Arkansas. It is the internal cast of an anonaceous seed, the ruminations being very clearly shown in the figure. The specimen is rather larger than any of those from Sheppey. Its ruminations are of the type found in certain species of *Anona*, and in *Anonaspermum anoniforme* from Sheppey.

The relationship of this American species to Anonaceae was further supported by the study of similar material from beds of Wilcox age in Bastrop County, Texas, collected by Dr. O. M. Ball. The material was first sent to Dr. R. Kräusel, by whom it was passed on to us for determination. The account of this material, *Anonaspermum reidi* Ball, was published by Ball (1931, p. 121, pl. xx, figs. 5, 9, 11). Subsequently to its determination we were informed by Dr. Ball that he had found leaves of one of the Anonaceae in the same deposit.

Recently (1930, p. 70, pl. xli, figs. 14, 18) Professor Berry has described a seed which he named *Anona robertsi* from the Lower Eocene Wilcox Beds of the southeastern United States.

As regards the later Oligocene and Miocene occurrences of Anonaceae, except in the case of *Alphonsea* cf. *lutea* described by Dr. Elise Hofmann (1930, p. 50, pl. v, fig. 33) from the Brown Coal of the Geiseltal and Gaumnitz, we can find no evidence, either descriptive or pictorial, that warrants reference of fruits to this family.

Genus ANONASPERMUM O. M. Ball emend.

Diagnosis.—Seeds anatropous, with ruminate albumen of the various types found in the family Anonaceae, and with an encircling band of fibres formed by the raphe and chalaza, which divides the seed into more or less symmetrical halves. Hilum terminal.

The name *Anonaspermum* must be regarded as a group name for fossil seeds which clearly belong to the family Anonaceae, but which cannot be assigned with any certainty to a nearer relationship on account of the difficulty of discriminating between living genera and species. It follows that the different species of *Anonaspermum* need not be closely related.

Discussion.—We have been obliged to emend Dr. Ball's diagnosis chiefly because it is inadequate to distinguish definitely between the fossilized seeds of Anonaceae and the fossilized remains of certain endocarps belonging to other families. Comparable types of transverse ribbing occur, for instance, in the endocarps of some of the Rubiaceae. It might be extremely difficult, or impossible, to distinguish the impression of the flat face of an endocarp of *Psychotria*, as well as of some other genera, from impressions of some of the seeds of Anonaceae, unless the encircling girdle of fibres were present to define the latter. Again, it might be impossible to distinguish internal casts or impressions of the pitted bisymmetric endocarp of certain Icacinaceae (*Pyrenacantha* and *Chlamydocarya*) from the pitted internal casts of anonaceous seeds unless the same encircling girdle were present. But beyond this it seems very undesirable to restrict the diagnosis of a fossil genus, which should be a form-genus for the whole family, to comparison only with " the seeds of certain of the extant Anonaceae, more especially to those of Anona, Asimina, and Guatteria " (Ball, 1931, p. 121). It is true that these three genera include the three main types of anonaceous seeds, and that reference to a complete range of their species might result in finding species which approached even some of the more anomalous types found among other genera, although we doubt it ; nevertheless it seems both unnecessary and undesirable so to restrict the comprehensiveness of a form-genus.

Anonaspermum commune n. sp.

Plate V, figs. 14–17.

Diagnosis.—Seed-casts ovoid, sometimes broader at one end, with a marked longitudinal median depression ; rumination ridges extending from the depression to the margins, close, and narrow, sub-parallel in the middle area ; four-partite in transverse section.

Holotype. V. 22217.

Description.—*Seed:* Large, ovoid, with a tendency to be rounder and broader at one end, slightly flattened laterally, bisymmetric ; anatropous, with hilum terminal at the blunt end and the raphe and linear chalaza forming an encircling girdle in the plane of symmetry and lying in a marked marginal groove; albumen often with a deep median longitudinal depression on each face, ruminate. Ruminations forming a series of rather narrow close ridges from the margin of the seed to the central depression; these ridges over the middle area are sub-parallel, towards the ends of the seed become more curved, at the narrow end tend to diverge from the end of the median depression, whilst at the broad end the distal ends of opposite ridges unite to form a series of curves, one within another. In all parts shorter ridges are frequently interposed between the longer ones (Pl. V, figs. 14, 15). In transverse sections of the seed the albumen shows a four-partite arrangement (Pl. V, fig. 17). The testa, which in this species is occasionally partly preserved, shows three coats: an outer coat of equiaxial or rather elongate polygonal cells irregularly oriented; a middle coat formed of several layers of fibres, still partially carbonized, which, being variously oriented, produce criss-cross striations; an inner coat lining the seed-cavity formed of small polygonal cells (0·026 mm. in diameter) which give a nodular surface to the impression on a thin film of glistening pyrites, but on the seed itself must have produced a pitted surface. Tegmen (seen on the surface of the cast of the albumen) formed of irregularly oblong cells with delicate sinuous margins, which form irregular striations along the ridges of the albumen. Length of cast, 9 to 15 mm.; breadth, 7·5 to 11 mm.; thickness, 4 to 8 mm.

Remarks.—Sixty-five seeds in various stages of preservation. They vary considerably in size, but otherwise there is nothing to differentiate them. We therefore conclude that they all belong to one and the same species, and probably to a species with numerous seeds, because the seeds are variously distorted and compressed as though by mutual pressure during life.

Affinities.—This type of seed is one of the commonest among living Anonaceae, and occurs in many genera. Of all the species which we have examined, those most closely resembling the fossil are *Polyalthia longifolia* Benth. & Hook. f. and *P. viridis* Craib. But in view of the close resemblance between the seeds of certain species in different genera, and of the differences between the seeds of species within a single genus, we do not feel justified in making any definite suggestion as regards the affinities of this fossil.

V. 22217 Holotype, figured Pl. V, fig. 14. A well-preserved, typical seed-cast.
V. 22218 Figured Pl. V, fig. 15. A seed-cast, slightly distorted, figured to show the attachment and raphe band.
V. 22219 Figured Pl. V, fig. 16. A seed-cast, figured to show the raphe band encircling the apex of the seed.
V. 22220 Six good seed-casts.
V. 22221 Twenty-one seed-casts in various states of abrasion and distortion. One at least shows traces of the true external surface of the testa lying within the lateral groove.
All the above are from the Bowerbank Coll., Sheppey.
V. 22222 Thirty-five seeds. *Reid & Chandler Coll.*, Minster, 1929.
The specimen figured Pl. V, fig. 17, has decayed since being photographed.

Anonaspermum rotundatum n. sp.

PLATE V, figs. 18–20.

DIAGNOSIS.—Seed-casts sub-globose, broader at one end, scarcely compressed, with very slight marginal groove; rumination ridges narrower, closer, and more complicated than in *A. commune,* a few only being parallel in the middle; four-partite in transverse section.

HOLOTYPE.—V. 22223.

DESCRIPTION.—*Seed:* Almost globose but usually rather broader at one end than the other, scarcely flattened, bisymmetric; anatropous, with the hilum terminal at the broader end and raphe and chalaza lying in a slightly marked marginal groove; albumen ruminate, ruminations forming narrower and more complicated ridges than in *A. commune,* lateral faces with a median area from which the ridges diverge, which may or may not be depressed. About the middle of the seed a few ridges are parallel, but at the ends they are arranged as in *A. commune,* being radially aligned at the narrower end, and united to form curves at the broader (Pl. V, fig. 18); but both radial and curved arrangements are more conspicuous in this species than in *A. commune.* The albumen shows a four-partite arrangement in transverse section (Pl. V, fig. 20). Testa formed of fibres (carbonized) so far as it is preserved; the external surface is not preserved, and the internal surface appears to be transversely striate. Tegmen finely striate as seen on the surface of the albumen. Length of seed, 7 to 12 mm.; breadth, 6 to 11 mm.; thickness, 5·5 to 7·5 mm.

AFFINITIES.—Eighteen specimens, differing somewhat in size, but showing consistently the features described above. The globose shape, smaller size, absence of long, deep, median depressions, less deeply incised marginal grooves, and the finer closer ridges of the albumen appear to differentiate this species from *A. commune* to which it otherwise bears a close general resemblance. The seeds are sometimes distorted, although less so than in *A. commune.* There is no evidence as to the number of seeds in the fruit—one, few, or many. Among living species the most comparable seeds are those of certain species of *Polyalthia,* which, however, are larger and more elongate.

V. 22223 Holotype, figured Pl. V, fig. 18. A seed without testa.
V. 22224 Figured Pl. V, fig. 20. A second typical seed, sectioned to show the arrangement of the albumen. Testa not preserved.
V. 22225 Figured Pl. V, fig. 19. A seed, hilar end without testa.
V. 22226 A seed, without testa.
V. 22227 Nine seeds, without testa.
All the above are from the Bowerbank Coll., Sheppey.
V. 22228 Five seeds without testa. *Reid & Chandler Coll.,* Minster, 1929.

Anonaspermum rugosum n. sp.

PLATE V, figs. 21–24.

DIAGNOSIS.—Seed-casts oval, the two ends alike, flattened, marginal groove deep; rumination ridges broad, more or less parallel in the middle, clubbing or forking towards the margin; four-partite in transverse section.

HOLOTYPE.—V. 22229.

DESCRIPTION.—*Seed:* Ovate, somewhat flattened, with no marked difference between the two ends; anatropous, with terminal hilum, raphe and chalaza lying in a deep marginal groove; albuminous, the albumen ruminate; ruminations rather coarse extending from a long slightly depressed median area on each face to the margin, where there is a distinct tendency either to club or fork, at the two ends diverging from the median longitudinal depressions (Pl. V, figs. 21–23); albumen unequally or irregularly four-partite in transverse sections of the seed. Testa formed externally of polygonal cells, 0·016 to 0·025 mm. in diameter, within which is a thickness of delicate criss-cross fibres; the surface of the seed-cast shows both fine striae and the impressions of large, thin-walled quadrilateral cells, elongate in the same direction as the striations. We are uncertain as to the relationship of these two layers, but the fine striations probably belong to the tegmen, and the quadrilateral cells may form the inner coat of the testa. Length of seed, 8 to 10 mm.; breadth, 4·5 to 7 mm.; thickness, 3 to 3·1 mm.

AFFINITIES.—Eight perfect specimens. The living genus *Goniothalamus* Hook. f. & Thoms. has albumen showing similar characteristics, but since this type of seed is fairly common among living Anonaceae, no suggestion as to its nearer affinities can be made.

V. 22229 Holotype, figured Pl. V, figs. 21, 22. A seed with part of the testa still preserved.
V. 22230 Figured Pl. V, fig. 23. A seed with the testa abraded, showing the arrangement of the albumen at the centre of the seed.
V. 22231 Figured Pl. V, fig. 24. A seed, fractured to show the arrangement of the albumen.
All the above are from the Bowerbank Coll., Sheppey.
V. 22232 Five specimens with abraded testa and the albumen (internal cast of testa) exposed. *Reid & Chandler Coll.*, Minster, 1929.

Anonaspermum pulchrum n. sp.

PLATE V, figs. 25–27.

DIAGNOSIS.—Seed-cast ovoid, uncompressed, convex on both faces, marginal groove slight; rumination ridges close and regular sometimes grooved longitudinally, many continued from margin to margin; four-partite in transverse section.

HOLOTYPE.—V. 22233.

DESCRIPTION.—*Seed:* Ovoid, not compressed, convex on both faces (one specimen shows very slight median longitudinal depressions); anatropous, with the raphe and chalaza lying in a rather inconspicuous marginal groove; albuminous, the albumen ruminate and ridged; the ridges, which are parallel and often continued from margin to margin in the middle of the seed but diverging at the two ends (Pl. V, fig. 26), have a tendency to be grooved along their length. Testa formed of criss-cross fibres, finely punctate on its inner surface. Surface of the albumen finely striate with indications of larger quadrate cells as in *Anonaspermum rugosum*, although the cells are smaller than in that species. Albumen four-partite in transverse section (Pl. V, fig. 27). Length of seed, 6·5 to 7 mm.; breadth, 4·5 to 5 mm.; thickness, 4 to 4·5 mm.

Affinities.—Three well-preserved specimens showing very uniform characters. The species is distinguished from the other London Clay Anonaceae by its generally compact form and by the absence of compression, also by the fineness and regularity of the ruminations and their frequent continuity from margin to margin across the middle of the seed. The uniformity of contour probably indicates that there was only one seed in the berry.

We found similar characters in *Dasymaschalon clusiflorum* Merrill, in which a typical seed measures 8·5 mm. in length; 6·5 mm. in breadth; 6 mm. in thickness. The transverse section shows a quadripartite arrangement of the albumen, the proportions are similar to those of the fossil, and the seed, although somewhat larger, is of the same shape. The ruminations are rather coarse, but the lateral groove with the raphe and chalaza is very small and shallow. Many specimens have only one seed, but some have more. The testa is thin. As previously stated, seeds of different genera of Anonaceae often show so confusing a resemblance to one another, that it is impossible to be sure of relationship. We do not therefore imply that the species should be considered as related to *Dasymaschalon*, because it is possible that a more exhaustive search than we were able to make among the seeds of the Anonaceae might have led to the discovery of other genera having species with similar seeds. But we wish nevertheless to draw attention to this living Indo-Malayan genus with similar seeds.

V. 22233 Holotype, figured Pl. V, fig. 25. A seed, with remains of the testa.
V. 22234 Figured Pl. V, figs. 26, 27. A seed, fractured to show the arrangement of the ruminations.
V. 22235 A seed, somewhat broken at one end, with remains of the testa.
All are from the Bowerbank Coll., Sheppey.

Anonaspermum minimum n. sp.

Plate V, fig. 28.

Diagnosis.—Seed-casts ovoid, both faces uniformly convex, marginal groove very shallow; rumination ridges few, broad, irregular, and interrupted.

Holotype.—V. 22236.

Description.—*Seed:* Ovoid, the faces being uniformly convex without any central depressions, barely grooved at the margin; anatropous, the hilum being terminal and the raphe and chalaza lying marginally flush with the surface; albuminous, the albumen ruminate; the ruminations, which are relatively few and coarse for the size of the seed, form, except at the two ends where they diverge, a series of somewhat interrupted transverse ridges, some of which pass from margin to margin, whilst others end near the middle and interdigitate with those from the other margin. Testa formed of swirling strands of fine fibres, internal surface pitted. Length of seed, 5·5 mm.; breadth, 4 mm.; thickness, 4 mm. Length of seed (second specimen), 5·5 mm.; breadth, 4·2 mm.; thickness, 2·8 mm. Length of seed (third specimen), 5 mm.; breadth, 3·5 mm.; thickness, 4 mm. (distorted by lateral compression).

Affinities.—Three specimens. One has much of the testa preserved, the other two are worn so as to show the albumen. The species has a considerable resemblance in its general form, and the character of the ruminations, to *A. pulchrum*, but is distinguished by its smaller size, by the smaller number of its ruminations (the ridges being approximately of the same breadth in the two species), and by the frequent interruption of the transverse ridges about the middle of each face.

V. 22236 Holotype, figured Pl. V, fig. 28. A seed with testa abraded.
V. 22237 A seed with remains of testa.
V. 22238 A seed, with testa abraded, which has undergone lateral compression.
All Reid & Chandler Coll., Minster, 1929.

Anonaspermum punctatum n. sp.

Plate V, figs. 29, 30.

Diagnosis.—Seed-casts globose or distorted by mutual pressure, but not laterally compressed, marginal groove shallow; ruminations forming deep punctations over the whole surface.

Holotype.—V. 22239.

Description.—*Seed:* Sub-globose, or distorted by mutual pressure during life, but not laterally compressed when fully developed, and without any median lateral depressions; anatropous, with raphe and chalaza lying in a shallow marginal groove; albuminous, the albumen ruminate, the ruminations forming deep pits which are scattered fairly closely and uniformly over the surface; in radial sections of the seed the albumen shows a radial arrangement. Testa formed of fine criss-cross fibres. Surface of the albumen (tegmen) finely striate, the striations radiating outwards towards the margin. Diameter of equiaxial specimen, 5 mm.; length of second specimen, 7 mm.; breadth, 6 mm.; thickness, 5·5 mm.

Remarks.—Twelve complete seeds and one in fragments. One of the seeds is globose, another is ovoid, another is distorted probably in fossilization, a fourth is concave on one side—evidently the effect of mutual pressure of two seeds in the fruit, as the surface on this side is well preserved. The best preserved seed was found by us at Minster. This specimen shows very clearly the impression of cells directed away from the elongate chalaza in the marginal groove. At the extremity of the chalaza the striations radiate in all directions from it, but elsewhere they are directed at right angles from the chalaza and the raphe band.

Affinities.—Similar punctate ruminations occur both in the Icacinaceae (*Phytocrene*, *Chlamydocarya*, etc.) and in the Anonaceae. But the marginal groove, carrying an encircling strand of fibres formed by the raphe and chalaza, is found in Anonaceae only. Hence it is quite certain that the species above described belongs to this family. Punctate seeds occur in many genera of the Anonaceae, for example, in *Bocagea* St. Hil., *Orophea* Blume, *Polyalthia* Blume, *Unonopsis* R. Fries., *Guatteria* Ruiz & Pav., *Xylopia* Linn., *Melodorum* Hook. f. & Thoms., and *Rollinia* A. St. Hil. The punctations of the last three are comparatively few and scattered. Those of *Polyalthia* are many and close. The punctations most resembling those of the fossil species occur in *Bocagea*, *Orophea*, *Unonopsis*, and *Guatteria*.

V. 22239 Holotype, figured Pl. V, fig. 30. A seed-cast, somewhat crushed but showing beautifully the chalaza-raphe band and the arrangement of the pits in the albumen. *Reid & Chandler Coll.*, Minster, 1928.
V. 22240 Figured Pl. V, fig. 29. A seed-cast. *Bowerbank Coll.*, Sheppey.
V. 22241 Three seed-casts, one much compressed during growth, so as to be concave on one surface. Also fragments of a fourth seed showing the albumen in section. *Bowerbank Coll.*, Sheppey.
V. 22242 Seven seed-casts. *Reid & Chandler Coll.*, Minster, 1929.

Anonaspermum ovale n. sp.

PLATE V, figs. 31–33.

DIAGNOSIS.—Seed-casts oval, flattened, but with convex faces, without a marginal groove; rumination ridges wide, bold, branching from an irregular median ridge, and anastomosing to form large irregular pits; bipartite in transverse section.

HOLOTYPE.—V. 22243.

DESCRIPTION.—*Seed:* Oval in outline, markedly flattened but convex, not concave, in the middle of each face, without a marginal groove, bisymmetric; anatropous, the raphe marginal, but inconspicuous; albuminous, the albumen ruminate; ruminations very coarse and contorted, with a tendency to form a median ridge from which the other ridges diverge (Pl. V, figs. 31, 32). Owing to the branching and anastomosing of ridges there is also a slight tendency to produce a very coarse pitting of the albumen. Testa formed of many layers of tortuous intertwining fibres, lined internally by a layer of minute cells arranged in rows so that they give rise to striations diverging from the raphe. Surface of the albumen very finely striate. In transverse section there is a marked bipartite arrangement of the albumen (Pl. V, fig. 33). Length of first specimen, 12·5 mm. (imperfect); breadth, 9 mm.; thickness, 5 mm. Length of second specimen, 10 mm.; breadth, 7·5 mm.; thickness, 4·5 mm. Length of third specimen, 8 mm.; breadth, 5 mm.; thickness, 3·5 mm.

AFFINITIES.—Four perfect, or almost perfect specimens, and fragments of another. The species is very sharply differentiated from all the other London Clay species, save *Anonaspermum anoniforme* and *A. subcompressum*, by its markedly flattened form, by the great complication and contortion of the ruminations, and by the raised, instead of depressed, area in the middle of the flattened faces. This type of seed appears to be rarer among living species than that of *Anonaspermum commune* or *A. rotundatum*. The genera *Anona* and *Melodorum* both show some seeds which are comparable in a general way, *e.g. Anona muricata* Linn., *A. laurifolia* Dunal, *Melodorum latifolium* Hook. f. & Thoms.

V. 22243 Holotype, figured Pl. V, fig. 32. A seed with remains of testa, slightly broken at the hilar end.
V. 22244 Figured Pl. V, fig. 31. The perfect internal cast of a seed showing very clearly the arrangement of the albumen.
V. 22245 Figured Pl. V, fig. 33. A fractured seed showing the section across the albumen.
V. 22246 A seed with much of the testa remaining. The hilar end is slightly broken.
All are from the Bowerbank Coll., Sheppey.
V. 22247 An internal cast of a seed which may belong to this species. *Reid & Chandler Coll.*, Minster, 1929.

Anonaspermum complanatum n. sp.

PLATE V, figs. 34, 35.

DIAGNOSIS.—Seed-casts oval, flat, but slightly thicker in the middle and at the hilum ; rumination ridges thick, short, irregular, radiating and sometimes bifurcating at the margins.

HOLOTYPE.—V. 22248.

DESCRIPTION.—*Seed:* Oval in outline, flat, but very slightly thickened near the hilum and at the centre, marginal groove almost wanting ; anatropous, with terminal hilum, and the raphe and chalaza forming a slight marginal rim ; albuminous, the albumen ruminate ; the ruminations forming thick, short, radiating and sometimes bifurcating ridges around the margin, but quickly passing into a slightly raised central mass of short contorted ridges and nodules (Pl. V, figs. 34, 35). Testa formed of layers of fine fibres which frequently give rise to a criss-cross effect, lining of testa finely striate. Length of seed, 8·5 mm. ; breadth, 6·3 mm. ; thickness, 2 mm. Length of second seed, 8·5 mm. ; breadth, 6·5 mm. ; thickness, 2·5 mm. Length of third seed, 7·5 mm. ; breadth, 6·5 mm. ; thickness, 3 mm. Length of fourth seed, 7 mm. ; breadth, 6·5 mm. ; thickness, 2·5 mm.

AFFINITIES.—Four seeds, distinguished from the other fossil species by their exceptional flatness. This, together with their uniformly oval shape and the character of the ruminate albumen, radiating at the margin and nodular at the centre, gives them a very distinctive appearance. They most resemble *A. ovale* among the London Clay species, but are smaller, flatter, and have a rather more marked radial arrangement of ridges in the albumen.

V. 22248 Holotype, figured Pl. V, fig. 35. The internal cast of a seed.
V. 22249 Figured Pl. V, fig. 34. An internal cast of a seed with much abraded remains of testa.
V. 22250 Two internal casts of seeds, with remains of testa.
All are Reid & Chandler Coll., Minster, 1929.

Anonaspermum corrugatum n. sp.

PLATE V, fig. 36.

DIAGNOSIS.—Seed-casts elongate-oval, flattened, with both ends alike, marginal groove slight, raphe level with the surface ; ruminations forming divergent corrugations, except in the median area where they are zig-zag and anastomose so as to form large, deep pits.

HOLOTYPE.—V. 22251.

DESCRIPTION.—*Seed:* Elongate-oval in outline, flattened, with both ends alike, also the two faces ; anatropous, with raphe and chalaza neither prominent nor sunk ; albuminous, the albumen ruminate ; ruminations very irregular, forming irregular divergent corrugations between the margin and the less divided, slightly raised, central area, where the anastomosing of short zig-zag ridges sometimes produces deep pits. Lining of testa slightly striate, the striations being directed at right angles to the margin. Length of first specimen, 9 mm. ; breadth, 5·25 mm. ;

thickness, 3 mm. Length of second specimen, 8 mm.; breadth (including patches of testa), 5 mm.; thickness, 3 mm. Length of third specimen, 7 mm.; breadth, 4·5 mm.; thickness, 2·5 mm.

REMARKS.—Eight specimens from Sheppey. Seven were found by us; the eighth belongs to the Bowerbank Collection. It is much more worn than the others, but a certain amount of the testa having been preserved along one part of the margin, it appears broader. The corrugations of the albumen also appear simpler owing to the abrasion of the smaller prominences and branches. The species is somewhat similar to *Anonaspermum ovale*, but it is smaller and narrower, and the albumen shows a greater development of pits.

V. 22251 Holotype, figured Pl. V, fig. 36. An internal cast of a seed.
V. 22252 A similar seed-cast.
Both are Reid & Chandler Coll., Eastchurch, 1928.
V. 22253 A seed with remains of testa. *Bowerbank Coll.*, Sheppey.
V. 22254 Five internal casts of seeds. *Reid & Chandler Coll.*, Minster, 1929.

Anonaspermum anoniforme n. sp.

PLATE V, fig. 37.

DIAGNOSIS.—Seed-cast elongate-oval, both ends alike, flattened, but with slightly convex faces, marginal groove almost absent; rumination ridges mostly transverse, short, broad, and very irregular, sometimes forming nodulations, with a marked development of short ridges interpolated between the longer ones at the margin.

HOLOTYPE.—V. 22255.

DESCRIPTION.—*Seed:* Elongate-oval in outline, compressed, yet with both faces slightly convex, marginal groove almost wanting; anatropous, with terminal hilum, and raphe and chalaza very conspicuous; albuminous, with ruminate albumen; ruminations, which do not form central longitudinal ridges or depressions, mostly directed transversely, sometimes continued in a sinuous course across the centre, often anastomosing with those from the opposite margin or bending back or forking so as to produce nodules, sometimes interrupted, and with a marked development of short ridges narrowing inwards, which are interpolated between the longer ones at the margin. Testa too much polished by abrasion for examination although patches of it persist. Surface of the albumen finely striate. Length of seed, 12·5 mm.; breadth, 5·5 mm.; thickness, 4·5 mm.

AFFINITIES.—One specimen, perfect but for the abrasion of the testa; a second distorted seed may also belong to this species. The type specimen is comparable with species of *Anona* and *Polyalthia*. The seed of *Anona muricata* Linn., which it most closely resembles, is less elongate; also the ruminations are wider, and the striations of the albumen are coarser.

V. 22255 Holotype, figured Pl. V, fig. 37. An internal cast of a seed with remains of testa. *Bowerbank Coll.*, Sheppey.
V. 22256 A crushed seed-cast which may belong to *A. anoniforme*, but cannot be determined with certainty owing to its distorted condition. *Reid & Chandler Coll.*, Minster, 1929.

Anonaspermum sub-compressum n. sp.

PLATE V, fig. 38.

DIAGNOSIS.—Seed-cast oval, slightly flattened, raphe and chalaza narrow and rather prominent; rumination ridges very tortuous and complicated, forming central nodulations and marginal ridges.

HOLOTYPE.—V. 22257.

DESCRIPTION.—*Seed:* Ovate in outline, being broader and somewhat emarginate (? accidentally) at the hilar end, somewhat flattened; anatropous, with hilum terminal at the broad end and raphe and chalaza narrow and slightly prominent; albuminous, the albumen ruminate; ruminations very tortuous and complicated, with a tendency to form a nodular area in the middle of each face, interrupted transverse ridges near the margin in the middle of each side, more or less concentrically bent ridges at the broad end, and very conspicuous short ridges at the narrow end which radiate from a point situated at about two-fifths the length of the seed from that end. Length of seed, 6 mm.; breadth, 5 mm.; thickness, 3·5 mm.

REMARKS.—The one specimen appears to differ in form and in the character of its ruminations from all other Sheppey species.

V. 22257 Holotype, figured Pl. V, fig. 38. An internal cast of a seed. *Reid & Chandler Coll.*, Minster, 1928.

Anonaspermum obscurum n. sp.

PLATE V, fig. 39.

DIAGNOSIS.—Seed-cast oval, plano-convex (with a median groove on the flat face ?), slightly narrowed at one end; ruminations diverging round the margin, but forming pits in the middle.

HOLOTYPE.—V. 22258.

DESCRIPTION.—*Seed:* Oval in outline, flattened on one face, convex on the other, slightly narrowed at one end; anatropous, with marginal raphe and chalaza; albuminous, albumen ruminate; ruminations rather coarse and sinuous, tending both to branch and to form club-like ridges diverging from a median area which, on the flat face, shows a marked groove (whether natural or accidental we do not know), and on the convex face shows a larger area with a tendency to be pitted rather than ridged. Length of seed, 6·5 mm.; breadth, 4·5 mm.; thickness, 3·5 mm.

REMARKS.—One seed. The flattening of one face probably indicates that it belonged to a fruit in which more than one seed was developed. The seed is much abraded and poorly preserved; its affinities cannot be determined.

V. 22258 Holotype, figured Pl. V, fig. 39. An internal cast of a seed. *Bowerbank Coll.*, Sheppey.

Anonaspermum cerebellatum n. sp.

PLATE V, figs. 40–42.

DIAGNOSIS.—Fruit sub-globular, two-seeded, placentation parietal; pericarp formed of irregular cells with embedded fibres; 7·5 mm. long. Seeds plano-convex (the appressed faces being apparently flattened) ; raphe thick ; ruminations forming punctations over the middle and ridges at the margin.

HOLOTYPE.—V. 22259.

DESCRIPTION.—*Fruit:* Sub-globular, two-seeded, the seeds being situated slightly obliquely one above the other, placentation evidently parietal as the terminal hila of the seeds abut against the lateral wall of the fruit about half-way along its length (Pl. V, fig. 41) ; pericarp (about half is preserved) rather thin, much worn (?), formed of irregular cells among which strands of fibres are embedded which diverge from the attachment and converge to the apex. Length, 7·5 mm. ; diameter, 7 mm.

Seeds: Hemispherical or concavo-convex (?), appressed, but the appressed faces slightly inclined to one another as shown by the inclination of the planes through the raphes and chalazas ; anatropous, with encircling raphe and chalaza ; albuminous, the albumen ruminate ; ruminations complicated and contorted, tending to form irregular ribs near the raphe, and punctations over most of the rest of the surface, including the whole of the median area (Pl. V, figs. 41, 42) ; testa formed of several coats ; the outer, which is carbonaceous, has decayed too much for description, and is followed by a fibrous coat recognizable only by its impressions ; within comes a coat formed of delicate polygonal cells, the thin lateral walls of which are well preserved ; lastly there is a thin coat of overlapping fibres irregularly aligned. Length of seed, 7 mm. ; breadth, 6·5 mm. ; thickness, 3·5 mm.

REMARKS.—One fruit only is preserved. Over about half its surface, including the attachment region, the pericarp remains, but it has evidently been much abraded so that the epicarp has been worn away (Pl. V, fig. 40). The seed is in a different state of preservation from any other we have seen, as the testa remains, although over a great part of the surface it is only the two inner coats which have survived, the outer coats persisting only in a few small patches. In all other seeds of Anonaceae from the London Clay the testa has largely disappeared, leaving the internal cast of the seed. Its presence in this fossil species, as in living species, to some extent obscures the ruminations. Nevertheless there has been sufficient removal of the testa to render their essential nature clear.

AFFINITIES.—The parietal placentation and two-seeded fruit render unnecessary comparison with more than about ten genera of living Anonaceae, of which *Uvaria* Linn., *Melodorum* Hook. f. & Thoms., and *Orophea* Blume, appear to show the closest resemblance to the fossil. *Uvaria* and *Melodorum* are lianas inhabiting the tropics of east Asia, west Africa, and Australia. *Orophea* is a genus of trees and shrubs inhabiting tropical Asia.

The only fossil species at all comparable is *Anonaspermum obscurum*, but the evidence does not permit of placing them in the same species. *A. obscurum* is flatter and more elongate than *A. cerebellatum*, and its ruminations are rather less numerous, less pitted, and more ribbed.

V. 22259 Holotype, figured Pl. V, figs. 40–42. Two seeds surrounded by the remains of a fruit. *Bowerbank Coll.*, Sheppey.

LAURACEAE

INTRODUCTION

The Lauraceae is one of the best represented families in the London Clay; probably ranking second only to Nipaceae. Nevertheless, it was one of the latest we were able to determine. The reason was that the most obvious macroscopic character, that of a one-celled, one-seeded fruit, is in itself not distinctive, and it was long before we were able to recognize the less obvious characters, dispersed as they were among a confused mass of specimens, presenting the utmost diversity in size and appearance. It was not until we realized that the vertical groove seen on some specimens must indicate the presence of large plano-convex cotyledons in an exalbuminous seed that we began to contemplate possible relationship with Lauraceae. Even then, relationship with *Quercus* seemed equally possible, more especially because of the presence of cupules in a good many specimens. But a minute comparison with the integument and cupule of *Quercus* compelled us to abandon the idea of relationship. There remained Lauraceae. The work of determination was, however, still very slow, chiefly through our ignorance of the diagnostic characters of the family, but also because of the way in which those characters were displayed in the fossils. We had in our collection of living fruits and seeds a dozen or more species belonging to the family, and it was only by intensive study of these, in macroscopic and microscopic detail, that gradually we were able to recognize the essential characters. Yet even when we felt fairly certain of the representation of the family, there was a character of fossilization which made absolute determination difficult. This was that in the living species the raphe always formed a conspicuous network of fibres over the chalazal area, whereas in the fossils the corresponding area was smooth and shining. It was not until we realized that the fossils were represented by internal casts of this area and that they therefore showed the internal chalaza, which is smooth, that the difficulty resolved itself; for in the living forms it is the fibres of the chalaza that are most conspicuous. The external chalaza is formed by a network of fibres, the internal chalaza is smooth and shining. Hence the difficulty which beset us, and may perhaps puzzle future workers.

Having made this preliminary statement we will now note what are the diagnostic characters of the Lauraceae, and how they appear in fossilization.

(1) *Macroscopic Characters of the Fruit.*—The fruit may or may not be enclosed partially, or wholly, in the base of the accrescent perianth, *i.e.* it may or may not be cupulate; or, again, it may or may not be seated on a swollen receptacle. In those species in which the fruit is borne on a swollen receptacle there is a marked basal scar of attachment visible on the outer surface of the epicarp (Pl. VI, fig. 8). In those fossils which are partly enveloped by a cupule, the integuments may not be separable within the cupule, and the scar of attachment may be seen on the endocarp, or on the locule-cast (Pl. VII, fig. 23), and may be evidenced by a constriction of the endocarp (Pl. VII, figs. 17, 22). According to the nature of their

substance, the limits of endocarp and mesocarp may be clearly distinguishable in some fruits, whether they be living or fossil, whereas in other fruits it is extremely difficult to trace them. Whether this is due to the dried (or fossilized) condition in which alone we have been able to study these fruits we do not know. It may be. The fruits are always one-celled and one-seeded. The funicle enters the locule at the top through a large and, sometimes, very conspicuous foramen which is frequently transversely elongate, so as to appear as a mouth-like slit (Pl. VII, fig. 32). The placenta lies immediately within this foramen so that the seed is pendulous from the top of the locule.

(2) *Macroscopic Characters of the Seed.*—The seed conforms to the shape of the locule. It is anatropous, with the hilum contiguous to the placenta and the raphe along one side, its fibres branching over the large and conspicuous chalaza to form a network; the micropyle is adjacent to the hilum, but except in seeds in which the embryo is apiculate (Pl. VI, fig. 19), such as *Beilschmiedia*, it presents no characteristic feature. The seed is exalbuminous, the large appressed plano-convex cotyledons occupying almost the whole of the seed-cavity (Pl. VI, figs. 27, 29, 30; Pl. VIII, fig. 21). The junction of their flat faces is marked externally by a groove which is not infrequently indicated on fossil seed-casts. The tegmen in many species passes between the cotyledons, and we have been able to trace it in many of the fossils. So far as we have been able to study living species we have found that the chalaza has one of two forms. The most usual appears to be that in which it is circular and occupies the whole of the base of the seed (*i.e.* the base viewed in relation to the fruit, not to the hilum of the seed) sometimes to the extent of five-sixths, or more, of the surface (Pl. VI, figs. 9, 13, 14; Pl. VII, figs. 15, 28, 34, 37; Pl. VIII, figs. 15, 22). The less common form, certainly among the London Clay fossils, is for the chalaza to be irregularly ligulate with very sinuous margins, in which case it lies along the groove marking the junction of the cotyledons, as an encircling longitudinal band which may extend almost the complete length of the seed on both sides (Pl. VI, figs. 24, 28, 30, 31); in such cases the tegmen always passes between the cotyledons. Whichever of these forms the chalaza takes, the testa which covers it is always fused with the endocarp, whereas elsewhere over the surface of the seed it is free. In internal casts of seeds with circular chalazas, the chalazal area is smooth and shining so as to be very characteristic and easy to recognize. Lauraceae are more abundant in this state of preservation than in any other.

(3) *Microscopic Characters of the Fruit.*—As the endocarp is the most characteristic of the carpellary envelopes, and the one of which the remains are most commonly preserved, we will describe it first. So far as we have been able to observe, it is formed throughout, or its inner coat is formed, of small cells piled one upon the other so as to produce a columnar or palisade structure in radial sections of the fruit (Pl. VI, fig. 11; Pl. VII, fig. 11), whilst in surface view the cells may differ in size and shape in different species; sometimes they are elongate, sometimes angular, sometimes digitate and interlocking. The coat may be either thick or thin. When it is the only one present in the endocarp it is usually very conspicuous and is readily

detached from the exocarp. But in some species it is intimately associated with another which may in part belong to the endocarp, although in part it would seem to constitute the mesocarp, which otherwise would not be represented; but, if so, there is nothing to show where one coat ends and the other begins. The coat of which we speak is formed of irregularly dispersed parenchyma interspersed with large stellate clusters of cells (Pl. VI, figs. 18, 19, 25, 27, 32, 34). In *Endiandra*, and possibly in other genera which we have been unable to study, these characters are arranged like the "eye" and "ray" florets of a daisy, the cells forming the "eye" being small and densely clustered, those forming the "ray" being prismatic (Pl. VI, fig. 5); each "ray" may be formed either of one cell or of two or more placed end to end, those farthest from the eye being the longest. In other genera the "eye" cells are wanting, the cells being then arranged in simple radiating clusters. The stellate coat is often very thick, but the associated columnar coat is then usually very thin, and often intermittent; in this case it is very difficult to detect it either in living or fossil material. But whether thick, thin, or intermittent, the columnar coat appears always to form the innermost coat of the pericarp. If, therefore, it cannot be traced, doubt must arise as to whether the species belongs to the Lauraceae or not. Stellate clusters are not confined to the carpel, but may occur in the cupule also. Apart from the occasional occurrence of this stellate coat there is nothing characteristic about the mesocarp. The epicarp is always formed of a single layer of cells which superficially are equiaxial and give a shining, finely tessellated surface to the fruit, and in section appear as a thin columnar layer. So characteristic is this layer, that even within the walls of cupulate fruits it is frequently possible to trace it. The same also is true of the endocarp.

(4) *Microscopic Characters of the Seed.*—The testa may be formed of one or more coats; when of more than one, these differ in character, but almost invariably one is formed of large secreting cells which, in the fossil state, are filled with a shining black substance; they furnish one of the most characteristic features of the fossil Lauraceae. The walls of these cells appear to decay easily, for we find frequently that the cell contents have shrunk from them leaving an interspace which has become filled by pyrites within which lies the black secretion. If later the walls themselves have disappeared, the shining black secretions remain, each surrounded by a wall of pyrites, and isolated the one from the other (Pl. VI, figs. 10, 13). The tegmen is diaphanous and finely striate.

In regard to the determinations which follow, we have come to the conclusion that certain combinations of the above macroscopic and microscopic characters afford absolutely conclusive evidence of the presence of Lauraceae. Yet whilst it is possible to feel the greatest confidence as to the family position, the generic position may be extraordinarily difficult, perhaps impossible, to ascertain. The reason is that, except for the occurrence of cupules in some genera, enlarged receptacles in others, peculiarities in the form of the chalaza and in the structure of the carpellary coats in yet others, all other characters are extremely uniform. In the living, generic and specific differences frequently depend on colour, size, and shape, the actual or relative thickness of coats, and the sizes of cells, and so on; characters, some of which would be obliterated or destroyed in fossilization, whilst others it has been impossible for us to measure in the time and with the material at our command. Only in a few outstanding genera such as *Endiandra*, *Beilschmiedia*, *Cinnamomum* and *Protoravensara* (cf. living *Ravensara*), in which we have found characters which do not appear in other Lauraceae, accompanied by very characteristic form and structure, have we ventured on generic determinations or approximations. Yet even though the determined genera are few, the occurrence of this family in such great abundance and variety is a fact of great significance, and helps to emphasize the extremely warm humid climate in which the London Clay flora must have flourished.

In regard to previous records of Lauraceae from the London Clay, it is probable that No. 544 in Crow's manuscript catalogue, which represents a specimen found at Gravesend, Kent, and is described as " a fruit most resembling a hazel nut," is one of the Lauraceae. Also Nos. 46, 50, 454, the latter " much resembling the cup of an acorn." No. 483 may also be lauraceous, whilst 486 is a cupulate lauraceous fruit, possibly *Litsea pyriformis* (p. 204). No. 218 is *Crowella globosa* (p. 216), and No. 686 represents a seed with a lauraceous chalaza.

Ettingshausen listed *Laurus Lalages* (1879, p. 394), but the original of this species has not been seen by us, nor have we been able to recognize the genus *Laurus*, which has no very distinctive characters. The original of *Corylus primigenia* Ettingshausen (1879, p. 394) appears to have been traced and has proved to be a lauraceous berry (see *Laurocarpum ovoideum*, p. 228). It is probable that his three species of *Quercus* (1879, p. 394) also belonged to the Lauraceae, but the originals of these are not known.

Genus ENDIANDRA R. Brown

1810. Prod., p. 402.

Endiandra crassa n. sp.

PLATE VI, figs. 1–5.

DIAGNOSIS.—Fruit ovoid. Mesocarp thick, formed of two coats, the inner consisting of a single layer of coarse cells arranged in stellate groups. Endocarp with a large bilobed depression and beak-like prominence at the hilum ; wall thick (3 to 3·5 mm.), formed of parenchymatous cells arranged in smaller stellate groups than those of the mesocarp, having an intermittent columnar layer on the internal surface.

HOLOTYPE.—V. 22260.

DESCRIPTION.—*Fruit:* One-loculed, one-seeded, ovoid or sub-globular, thick-walled but easily distorted by compression. Epicarp thin, smooth, and polished externally but crumpled (? by shrinkage), formed of close, flat, thin-walled polygonal cells about 0·025 mm. in diameter. Mesocarp very thick, formed of two coats which show a different resistance to abrasion but are not separated by any very clear boundary. The outer, more resistant, coat is formed of cells which lie more or less parallel to the surface. The inner, less resistant, coat is always more or less decayed and worn ; it is formed of large cells arranged in flat stellate groups like the " eye " and " ray " florets of a daisy, the " eye " being formed of an agglomeration of small cells, the " rays " of large elongate cells sometimes as much as 0·2 mm. long, and 0·05 mm. broad (Pl. VI, fig. 5). The " ray " cells of adjacent stellate groups are shared in common. The layer which is formed of these cell-groups has a definite, rather uneven, internal surface and appears to be but one cell thick. It is possible that it really belongs to the endocarp, and not to the mesocarp as described above. Length of a fruit, 33 mm.; breadth (crushed), 28 mm.; thickness of exocarp, 2·5 mm.

Endocarp: Ovoid, but with a large longitudinally angled beak-like prominence which abuts upon a sunken cordate area, the surface of which is pierced by three large foramina for the passage of fibres (Pl. VI, fig. 4). Endocarp wall thick and woody, perhaps 3 or 3·5 mm. thick, formed throughout of parenchyma, the cells varying somewhat in size and being grouped in a similar manner to the stellate groups in the inner layer of the mesocarp described above, but since the cells of the endocarp wall are smaller, the stellate groups are also smaller. Further, there is rather obscure evidence that in the endocarp the groups are of three dimensions, because the thickness of the wall is also formed of them. Passing inwards are other stellate groups formed of progressively finer and finer cells. At intervals along the locule wall, the marginal cells belonging to the innermost groups are aligned at right angles to the surface of the locule; so that, intermittently, the wall as seen in section shows a columnar arrangement of the cells surrounding the locule. Thick fibre strands, which occasionally branch, run within the endocarp wall (Pl. VI, fig. 3). Length of a large endocarp, 33 mm.; breadth, 28 mm. Length of smaller endocarp, 22 mm.; breadth, 22 mm.

Seed: Sub-globular, pendulous, anatropous, testa rather thick, formed of more than one layer of coarse parenchyma, followed by a smooth glistening thin coat which lines the seed-cavity, formed of small oblong or polygonal cells aligned longitudinally so as to give a finely striate surface. Chalaza large, smooth, occupying the half of the seed remote from the hilum (Pl. VI, fig. 2).

Remarks.—Seven specimens. Two are fruits with much of the exocarp preserved. Both are much distorted, one laterally, the other dorsi-ventrally. One fruit showing the shrunken seed through a break in the carpel wall (Pl. VI, fig. 1) was fractured so as to liberate the seed (Pl. VI, fig. 2). A third specimen, taken as the holotype, represents an endocarp with patches of the well-preserved exocarp adhering (Pl. VI, fig. 4). The remaining specimens are endocarps; one is in fragments and shows a shrivelled seed within; another is broken, with a well-developed but broken seed.

Affinities.—The form of the large endocarp at once suggested relationship to the Lauraceae, but we at first regarded the determination as extremely doubtful because at that time we had not seen the peculiar stellate groups of cells in the fruits of this family. A long investigation of the Lauraceae in Kew Herbarium subsequently showed that these cell-groups are actually present in and, indeed, are typical of certain genera. In size, shape, and cell-structure the fossils most resemble the genus *Endiandra*. In this genus, the epicarp is as in the fossil, the mesocarp is formed for the most part of loosely-compacted tissue, more compacted towards the periphery; between the mesocarp and endocarp is a layer, one-cell thick, of large, thin-walled cells grouped in flat stellate clusters exactly as in the fossil. We are not sure whether this layer is part of the mesocarp or of the endocarp. The endocarp is hard and woody, formed of three-dimensional stellate groups of cells smaller than those of the layer just described. As in the fossil, the innermost layers form an intermittent columnar coat in proximity to the locule. Embedded between the endocarp and testa there are thick strands of fibres, but whether these are the fibres of the raphe or are merely fibres forming part of the endocarp wall we had not material at our command to ascertain. It appears, however, that whatever be the morphological significance of the structures described in the fossil and in the living, they are the same in both. The only distinction that we can discover between the two is that the pericarp is very much thicker in the fossil than in the living, but this may be due to shrinkage and contraction of the dried herbarium specimens, a process prevented in the fossils by the infiltration and hardening of fine-grained pyrites. We ought also to draw attention to the placental beak in the fossil, as we do not know whether it occurs in the living *Endiandra* or not, because we have never seen this part of the endocarp in the living fruit. The mesocarp of *E. Lowiana* Bailey measures 0·9 mm. in thickness, and the endocarp, 1 mm. We have named the fossil *Endiandra crassa*.

Endiandra is a genus inhabiting the Malay Peninsula and Archipelago, the Fiji Islands, and south-eastern Australia.

V. 22260 Holotype, figured Pl. VI, fig. 4. An endocarp, with remains of the mesocarp and epicarp. The specimen shows the beak-like prominence and sunken cordate area associated with the placenta, and the stellate grouping of the cells.

V. 22261 Figured Pl. VI, figs. 1, 2, 3. A fruit, now fractured; the epicarp and mesocarp are preserved; the seed is much shrunken from the endocarp. The specimen was originally perfect except for a hole in the exocarp and endocarp, through which the seed-cast could be seen, but it was much distorted by compression.

V. 22262 Figured Pl. VI, fig. 5. An endocarp, somewhat distorted, showing the stellate grouping of the cells (mesocarp or endocarp?) very clearly.

V. 22263 A much distorted fruit, which has been compressed dorsi-ventrally; the exocarp is much worn and abraded, the endocarp is exposed at the apex. The smooth chalazal area of the seed is exposed at the base.

V. 22264 An elongate endocarp, somewhat distorted, showing the beak-like prominence and the cordate depression of the placental region.

V. 22265 A broken endocarp, showing the placental region and the seed.

V. 22266 An endocarp, now much broken, containing a shrivelled seed.

All are from the Bowerbank Coll., Sheppey.

Genus CINNAMOMUM Blume

1825. Bijdr. Fl. Nederl. Ind., p. 568.

Cinnamomum globulare n. sp.

PLATE VI, figs. 6–11.

1879. *Diospyros eocenica* Ettingshausen (pars), p. 394.

DIAGNOSIS.—Berry sub-globular, 10 to 12 mm. in diameter, without cupule. Mesocarp thick, formed of equiaxial or fusiform cells radially aligned at the periphery.

Endocarp about 0·5 mm. thick. Seed sub-globular, chalaza occupying a third of the length ; testa formed of several (three ?) layers, the cells of the middle layer being secretory, irregular in form, and from 0·1 to 0·5 mm. in diameter. Embryo with small radicle and closely appressed cotyledons.

Holotype.—V. 22267.

Description.—*Fruit:* A one-loculed, one-seeded berry, sub-globular or ovoid, with a large circular scar of attachment at the base (Pl. VI, fig. 8), surface smooth and shining (Pl. VI, fig. 6). Pericarp thick, formed of three layers. A thin epicarp, which appears to be somewhat leathery, columnar in section, formed of fine polygonal cells, 0·025 mm. in diameter, which give a finely tessellated surface. A thick mesocarp, formed of several layers of large, elongate, fusiform or equiaxial cells, becoming largest towards the periphery, where they tend to be radially aligned. A thin endocarp, about 0·5 mm. thick, formed of polygonal cells (about 0·05 mm. in diameter) with rather confused outlines as seen in surface view, and with columnar arrangement as seen in radial sections of the fruit (Pl. VI, fig. 11). Seed pendulous from the apex. Length of berry, about 10 to 12 mm. ; breadth, about 10 mm.

Seed: Sub-globular, anatropous, with hilum at one end, raphe lateral (Pl. VI, fig. 10), chalaza large, almost hemispherical, at the opposite end (Pl. VI, fig. 9), and micropyle adjacent to the hilum. Testa formed of three layers of cells ; the cells of the outer layer irregularly polygonal in shape ; those of the next layer, which are of very variable size and shape (from 0·1 to 0·5 mm. in diameter), have sinuous outlines and are filled with a black secretion (Pl. VI, fig. 10) ; those of the innermost layer are minute and polygonal. Embryo exalbuminous, radicle small, cotyledons hemispherical, plano-convex and parallel. Diameter of a typical seed, 7 to 7·5 mm.

Remarks.—Forty-five specimens, of which three were found at Herne Bay, the remainder at Sheppey. One fruit was in a jar, with a lauraceous fruit of a different type, labelled by Ettingshausen "*Sabal punctata*," but this specific name does not appear in his provisional list of Sheppey fossils. A second specimen was labelled "*Carpolithes* sp. 10" by him, and a third, associated with other fruits of Lauraceae, was labelled "*Diospyros eocenica*." The most perfect specimens have a smooth unbroken epicarp, but the majority of the fruits have a nodular surface (Pl. VI, fig. 7). Initially this is probably due to the shrinkage of the succulent mesocarp, for we find in dried specimens of living fruits that this tends to shrink, producing crumples or nodulations of the epicarp, the manner of shrinkage being in some degree characteristic of a species, so that all shrunken berries of one species of cinnamon present a similar appearance. But following the initial shrinkage came pyritization and, later, abrasion. The effect of abrasion is seen in the fact that the epicarp is intact over the whole surface except the apices of the nodulations—the surfaces which first meet the forces of abrasion—where it is worn away. A further stage of abrasion is shown by other fruits which are pitted instead of nodular. In these, after the removal of the whole nodules, the loose-textured mesocarp within, with its large cells unprotected by the epicarp, has been easily worked on by the forces of abrasion, and so the surface became pitted.

Affinities.—There can be no doubt that the berries are those of Lauraceae.

From the fact that all show the same basal scar of attachment, and that none, not even the best preserved, shows traces of adherent mud such as might have infiltrated between the berry and a cup-shaped cupule, it seems almost certain that no such cupule ever existed, and that the peduncle must have been either flat or convex. The considerable size of the attachment scar suggests that it was swollen. The structure of the berry, particularly the character of the epicarp and of the secreting cells of the testa, is so remarkably like that of *Cinnamomum camphora* Nees & Eberm. that we think the specimens should be referred to the genus *Cinnamomum*.

V. 22267 Holotype, figured Pl. VI, fig. 6. A berry, broken on one side to show the endocarp and mesocarp in section. The secreting cells of the testa are exposed (somewhat worn) over the surface of the seed. The large attachment scar is clearly seen. The epicarp is well-preserved.

V. 22268 Figured Pl. VI, fig. 7. A berry, showing the characteristic nodular surface due to decay and abrasion of the epicarp. Pyrites has accumulated around the patches where decay is most pronounced.

V. 22269 Figured Pl. VI, fig. 8. A similar berry, showing the attachment scar very clearly.

V. 22270 Figured Pl. VI, fig. 11. A broken berry, showing the columnar structure of the endocarp in section.

V. 22271 Figured Pl. VI, fig. 10. A broken berry, fractured in order to release the seed. The secreting cells of the testa are preserved over the surface; the lateral raphe, clearly indicated by the elongation of the testa cells, is in this layer. From the chalazal end of the seed the testa has been chipped away so as partially to expose the chalaza; indications of the two cotyledons are seen on its surface in the slight but definite transverse furrow which forms a continuation of the line of the raphe.

V. 22272 Figured Pl. VI, fig. 9. A fruit fractured to liberate the seed. The testa is in part preserved, but has in part been chipped away to expose the limits of the large hemispherical chalaza.

V. 22273 A broken berry, showing the columnar structure of the endocarp.

V. 22274 A berry, fractured to expose the seed with its testa cells beautifully preserved.

V. 22275 A small berry, with a mass of pyrites marking the remains of the peduncle, fractured on one side to show the cast of the seed-cavity, reproducing clearly the two cotyledons. It probably belongs to this species.

V. 22276 A berry, fractured to show seed and testa.

V. 22277 A berry, fractured so as to liberate the seed, on which the testa is well-preserved.

V. 22278 A much contracted and distorted berry, with very rugose surface, now shattered to show the structure. Labelled by Ettingshausen "*Carpolithes* sp. 10."

V. 22279 Twenty-four berries.

V. 22280 A seed with remains of the fruit. Labelled by Ettingshausen "*Sabal punctata*."

V. 22281 A broken berry, labelled by Ettingshausen "*Diospyros eocenica* Ett."

All the above are from the Bowerbank Coll., Sheppey.

V. 22282 Four fruits. *Reid & Chandler Coll.*, Sheppey.

V. 22283 Three fruits. *D. J. Jenkins Coll.*, Herne Bay.

Cinnamomum grande n. sp.

Plate VI, figs. 12–14.

Diagnosis.—Berry sub-globular, 13 or 14 mm. in diameter, without a cupule; mesocarp formed of small uniform parenchyma; endocarp about 0·1 mm. thick. Seed sub-globular, conical at the hilar end; testa formed of more than one layer of secreting cells (many measuring 0·2 mm. in diameter) and of two hyaline inner layers; chalaza occupying two-fifths the length of the seed.

Holotype.—V. 22284.

Description.—*Fruit:* A berry, one-loculed, one-seeded, with the seed pendulous from the apex, sub-globular, but slightly conical at the apex, with a large circular scar of attachment, surface smooth and shining (corrugated by shrinkage in two specimens) sometimes with conspicuous circular punctations (whether structural, or accidental effects of fossilization and abrasion, we do not know, Pl. VI, fig. 12). Epicarp thin, brown and semi-translucent in patches (tough and leathery ?), formed of cells varying from 0·016 to 0·025 mm. in diameter which form a finely tessellated surface, and in section present a columnar appearance. Mesocarp fairly thick (much shrunken), formed of many layers of small uniform parenchymatous cells. Endocarp about 0·1 mm. thick, formed of layers of cells having confused superficial outlines, but presenting a regular columnar appearance as seen in radial sections of the fruit. Diameter of berry, 13 or 14 mm.

Seed : Sub-globose, conical at the hilar end, with large plano-convex appressed cotyledons, anatropous, with a large hemispherical chalaza (Pl. VI, fig. 14) at the broad end. Testa formed of more than one layer (probably two) of large secreting cells (Pl. VI, fig. 13), the cells of the outer layer being more or less fusiform, those of the inner layer being hexagonal ; they are filled with a black substance, and many cells measure 0·2 mm. in diameter. Within the layers of secreting cells there appear to be two hyaline layers, the exact character of the cells being obscure, but one specimen shows evidence of small sharply angled polygonal cells, best seen over the chalaza. Embryo exalbuminous with two parallel plano-convex cotyledons (Pl. VI, figs. 13, 14). Length of seed, 11 mm. ; breadth, 10 mm.

Remarks.—Five specimens besides several doubtful ones. One is an imperfect berry with the seed partly exposed (Pl. VI, fig. 13). Two are internal casts of seeds (Pl. VI, fig. 14), one having the remains of the testa. The other two specimens show merely the exterior of the berry with punctate epicarp, the punctations (glands ?) being emphasized by an infilling of pyrites (Pl. VI, fig. 12) ; both have undergone dorsi-ventral compression.

Affinities.—There can be no doubt that the berries belong to Lauraceae. The large, flat, basal scar probably indicates a large, flat (or convex), swollen peduncle, or small cupule. The large secreting cells, and the structure of the coats suggest an alliance with *Cinnamomum*. Similar, but somewhat smaller secreting cells have been found in *C. camphora*.

V. 22284 Holotype, figured Pl. VI, fig. 13. A berry, fractured on one side to expose mesocarp, endocarp, testa, and internal cast of seed. *Bowerbank Coll.*, Sheppey.

V. 22285 Figured Pl. VI, fig. 14. An internal cast of a seed, showing the chalaza ; the groove indicating the two cotyledons is clearly marked. *Bowerbank Coll.*, Sheppey.

V. 22286 Figured Pl. VI, fig. 12. A berry, somewhat crushed dorsi-ventrally, showing punctations of the surface. *D. J. Jenkins Coll.*, Herne Bay.

V. 22287 An imperfect but similar berry. *Reid & Chandler Coll.*, Sheppey, 1928.

V. 22288 A seed with remains of testa and endocarp. *Bowerbank Coll.*, Sheppey.

V. 22289 Three fruits, two fractured, one with a seed preserved. They may belong to this species. *D. J. Jenkins Coll.*, Herne Bay.

V. 22290 Five internal casts of endocarps, or seed-casts with part of the endocarp preserved. They may be identical with, or closely related to, the species just described. The specimens vary in size, and some are comparatively small. The endocarp and testa are similar to those in the typical specimens, but the secreting cells of the outer layer appear to be rather smaller. As, however, but a small area of these cells can be seen in *C. grande*, the difference may merely depend on the position on the surface at which the cells are exposed. *Bowerbank Coll.*, Sheppey.

Genus LITSEA Lamarck

1789. Encyc., III, p. 574.

Litsea pyriformis n. sp.

PLATE VI, figs. 15–17.

1879. *Elaeis eocenica* Ettingshausen (pars), p. 393.

DIAGNOSIS.—Berry enclosed for about three-quarters of its length in an obconical cupule. Mesocarp formed of five or six layers of small, radially-compressed cells. Endocarp 0·15 to 0·2 mm. thick. Placenta sub-apical. Chalaza occupying about one-third of the length of the seed.

HOLOTYPE.—V. 22291.

DESCRIPTION.—*Fruit:* A one-loculed, one-seeded berry, enclosed for about three-quarters of its length within an obconical cupule, which is the swollen receptacle; the walls of this are very thick and formed of coarse parenchyma, fibres, and large tortuous cells (Pl. VI, figs. 15, 16). Globular secreting cells, often 0·05 mm. in diameter, are scattered through the substance of the cupule, being especially abundant towards the periphery. Epicarp 0·1 mm. thick, surface not seen; in section the cells have a columnar arrangement. Mesocarp very thin, formed of a few (five or six ?) layers of small cells compressed in a radial direction. Endocarp about 0·15 to 0·2 mm. thick, formed of cells with a columnar arrangement (Pl. VI, fig. 17) as seen in the radial section of the fruit, the columns being about 0·03 mm. in diameter. At a point level with the margin of the cupule the wall of the endocarp (as seen in longitudinal section) is pierced by an aperture through which a bundle of fibres enters from the direction of the base of the fruit, passing within the endocarp towards the apex. This must be the funicle, and indicates a sub-apical placenta and a pendulous seed. Length of cupule, 14 to 16 mm.; breadth, 11 to 13·5 mm. Length of endocarp, 6 to 7 mm.; breadth, 8·5 mm.

Seed: Sub-globular, anatropous, the chalaza as viewed in relation to its position in the fruit occupies the lower third, and below its circular margin the seed is slightly constricted. The testa is relatively thick for Lauraceae; it is formed for the most part of a mass of loose parenchyma, but we cannot say whether or not this is glandular. Between these layers of the testa and the endocarp there is a layer of oblong or polygonal cells, about 0·1 mm. long and 0·05 mm. broad; as a result of fossilization it is fused both with the columnar coat of the endocarp and with the coat of the testa already described; but the fact that the columnar coat is the innermost coat in the endocarps of Lauraceae, and the appearance of a black secretion in the cells, makes it practically certain that it belongs to the testa. The dimensions of the seed could not be accurately ascertained; it is slightly smaller than the endocarp.

REMARKS.—Four specimens; in three the berry is preserved, and in the remaining specimen it has fallen out of the cupule. The epicarp in all these is fused with the cupule, whether originally, or as a result of pyritization (the pyrites acting as a cement) we cannot tell; in any case the result is that, when the berry falls from the cupule, the part of the epicarp which was in contact with the cupule remains behind still firmly adhering to it.

Affinities.—The relationship to the Lauraceae is clearly evidenced by the structure of the cupule, the fruit, and the seed. The only living genera with comparable cupules are *Litsea* and *Ocotea*. The thick enclosing cupule has a much greater resemblance to the cupules of the former; the fruits are similar to those of *Litsea fenestrata* Gamble, but smaller. We have therefore referred the specimens to *Litsea*.

In Crow's manuscript catalogue (1810, No. 486), a berry in a cupule is depicted which may belong to the species described above.

V. 22291 Holotype, figured Pl. VI, figs. 15–17. A berry in its cupule, fractured to show the structure. The epicarp is abraded.
V. 22292 A cupule from which the berry has fallen.
V. 22293 A cupule containing a berry.
V. 22294 A cupule containing a berry. Labelled by Ettingshausen "*Elaeis eocenica* Ett."
All are from the Bowerbank Coll., Sheppey.

Genus BEILSCHMIEDIA Nees

1831. In Wallich, Pl. As. Rar., II, p. 69.

Beilschmiedia oviformis (Bowerbank)

Plate VI, figs. 18–22.

1840. *Petrophiloides oviformis* Bowerbank, p. 49, pl. x, figs. 10, 11.
1845. *Petrophiloides oviformis* Bowerbank: Unger, p. 229.
1850. *Petrophiloides oviformis* Bowerbank: Unger, p. 427.
1851. *Petrophiloides oviformis* Bowerbank: Ettingshausen, p. 715.
1879. *Petrophiloides oviformis* Bowerbank: Ettingshausen, p. 394.

Diagnosis.—Fruit ovoid, about 12 or 13 mm. long; pericarp (as preserved) formed of two coats, an outer coat (0·75 to 1 mm. thick, formed of cells arranged in stellate groups, an inner intermittent coat (0·075 to 0·1 mm. thick) formed of cells deeply-rayed and interlocking superficially, but with columnar arrangement as seen in sections. Seed apiculate-ovate. Embryo with apiculate radicle and appressed plano-convex cotyledons, the tegmen penetrating between them.

Neotype (? Holotype).—V. 22295.

Description.—*Fruit:* An ovoid, one-loculed, one-seeded berry. Epicarp abraded. Carpel wall (as preserved) formed of two coats, the outer, about 0·75 to 1 mm. thick, has on its surface large stellate groups of cells. The groups may measure as much as 1·5 mm. in diameter; the central cells of each group are small, the larger peripheral cells of neighbouring groups are shared in common, each group merging with its neighbours. The central cells are frequently less pyritized than the peripheral, consequently differential decay and abrasion have often caused them to disappear, and the external surface of the coat appears coarsely pitted (Pl. VI, fig. 18). Similar stellate cell-groups occur throughout the coat as seen in section. Its inner surface, distinguishable only in part, shows a very thin layer of fibres (?), but whether these fibres are continuous over the whole inner surface it is impossible to tell. It is pierced at the apex by a conspicuous conical canal (Pl. VI, fig. 19) in which lies the conical radicle of the seed (Pl. VI, fig. 20). Within the coat, and separated from it by a layer of structureless pyrites, which indicates that separation took place prior to fossilization, is a thin intermittent columnar coat about 0·075 to 0·1 mm. thick, formed of deeply-rayed interlocking cells, the centres of which tend to decay, thereby producing a pitted surface to the coat. Seed pendulous. Length of fruit (as preserved), 12 to 13 mm.; diameter, 9 to 10 mm.

Seed: Apiculate-ovate, anatropous, with the hilum at the apiculate end, and the long narrow chalaza extending almost the complete length of both sides along the line which marks the meeting of the two cotyledons, micropyle at the apiculation; embryo exalbuminous; cotyledons plano-convex, distinctly separated beyond the hypocotyl, the thin tegmen penetrating between them; radicle forming the apiculation (Pl. VI, fig. 22). Testa formed of a thin coat of parenchyma; tegmen thin, striate, formed of elongate polygonal or fusiform cells; it originates from thick bands of fibres lying along the groove which separates the cotyledons, and associated with the chalaza; near the hypocotyl (where the edges of the cotyledons become free) the fibres spread fanwise on both sides of the seed; these points mark the limits of the chalaza. The cells diverge from the fibrous bands obliquely, towards the apex of the fruit; hence the striations are at first directed obliquely upward, but ultimately become longitudinal and converge to the radicle. Length of seed, 9 to 10 mm.; diameter, 6·6 mm.

REMARKS.—Nine specimens; all but one are internal casts of seeds to which fragments of the testa and endocarp adhere, and all show the conspicuous division between the cotyledons (Pl. VI, fig. 22). The remaining specimen (V. 22295) is a seed-cast with the broken fragments of the carpel which forms a "shell." When pieced together the shell proved to be almost complete. It showed very clearly both the structure of the carpel and the conical stylar foramen (Pl. VI, figs. 18–21). The coat composed of stellate clusters of cells forms the main thickness of the shell, the fused columnar coat and testa form an inner shell which remains as an apical cap separated from the tegmen by pyrites (Pl. VI, fig. 20). Whether the coat with stellate clusters and the columnar coat together form the endocarp, or whether the latter coat only, the stellate coat being the mesocarp, we do not know. All specimens show the striate tegmen more or less clearly, and in some the parenchymatous testa is well-preserved. We were at first much puzzled by the apparent absence of a chalaza. Two specimens were therefore fractured along the plane of separation of the cotyledons. These readily separated, showing finished flat surfaces bearing the impressions of the tegmen cells. Thus it became evident that the chalaza in this species is a long ligulate area from which the cells of the tegmen diverge both over the appressed inner faces of the cotyledons and over their convex outer faces.

With the specimens described above must be included a fruit collected by Bowerbank below Minster Church and figured by him under the name *Petrophiloides oviformis* (1840, p. 49, pl. x, figs. 10, 11). It agrees closely in size with the perfect specimen described above, if we may judge by Sowerby's figures, which, however, merely show the outer surface. Unfortunately, Bowerbank's description and diagnosis ("*Cone* oviform, *Squamae* confluent") are so brief, inadequate, and misleading that they do not assist the comparison. There is nothing in the figures to suggest that the specimen was a cone. There seems to be no relationship to *Petrophiloides Richardsonii* Bowerbank, and we have seen no other Sheppey fruits comparable with *Petrophiloides oviformis* Bowerbank. We feel little doubt, therefore, that it belongs to Lauraceae, and it is quite possible that the specimen we have been describing may be the holotype of this species, which, otherwise, has disappeared; but in its present broken condition it is impossible to prove the identity.

Affinities.—We were at first greatly puzzled by these fruits with their stellate groups of cells, intermittent columnar coats, apiculate seeds with distinct cotyledons, and narrow strap-shaped chalazas. After prolonged study we found that these characters occur in some of the Lauraceae. Similar stellate groups of cells and intermittent columnar layers were seen in *Endiandra* and *Beilschmiedia*; conspicuously apiculate seeds were found in *Cryptocarya* and *Beilschmiedia*. Only in *Beilschmiedia*, however, did we see the combination of characters described above, including the strap-shaped chalaza associated with a thin layer of cells which is continuous with the tegmen and is intruded between the cotyledons. We have, therefore, referred the species to the living genus *Beilschmiedia*, which is now distributed throughout the tropics of the world, especially in Asia and Africa.

V. 22295 Figured Pl. VI, figs. 18–21. ? Holotype, figured Bowerbank (1840, p. 49, pl. x, figs. 10, 11). A fruit; carpel wall in fragments. It shows very clearly the structure of the wall, the conical apical canal associated with the radicle, and the remains of the columnar coat (endocarp ?) clinging to the internal cast of the seed.
V. 22296 Figured Pl. VI, fig. 22. An internal cast of a seed, showing the cotyledons and radicle.
V. 22297 Five casts of seeds.
V. 22298 An internal cast of a seed.
V. 22299 A rather large, somewhat shrivelled berry, which should probably be referred to this species.
All are from the Bowerbank Coll., Sheppey.

Beilschmiedia pyriformis n. sp.

Plate VI, figs. 23–25.

Diagnosis.—Fruit a berry, pear-shaped. Carpel (as preserved) formed of three coats: (1) a coat (2 or 3 mm. thick) formed chiefly of stellate groups of cells, embedded within which is a layer of branching and anastomosing fibres; (2) a coat of radially compressed parenchyma (0·4 to 1 mm. thick); (3) a columnar coat (0·1 mm. thick) apparently intermittent. Seed about three-quarters as broad as long. Embryo with apiculate radicle, chalaza ligulate with wavy margins, cotyledons with the tegmen intruded between them.

Holotype.—V. 22300.

Description.—*Fruit:* A one-loculed, one-seeded berry, not cupulate; pedunculate but not seated on a swollen receptacle, more or less pyriform. Carpel wall thick (epicarp not seen), formed (as preserved) of three coats: (1) the outer (from 2 to 3 mm. thick) is formed towards its exterior of parenchyma with stellate groups of cells, and towards its interior of stellate groups of cells only, which measure from 0·4 to 0·8 mm. in diameter, whilst between them occurs a layer of branching and anastomosing fibres; (2) the second coat, 0·4 to 1 mm. thick, is formed of radially compressed parenchyma; (3) the third coat (endocarp ?) is 0·1 mm. thick and is formed by cells having a columnar arrangement; it appears to be intermittent and is often displaced when the seed is distorted. Coats (1) and (2) often pass insensibly into one another without any clear-cut plane of demarcation. Length of fruit, 28 to 37 mm.; breadth, 23 to 26 mm.

Seed: Exalbuminous, mucronate-ovoid; testa formed of fine parenchyma; tegmen formed of small oblong cells which, arranged end to end, give rise to striae, the striations diverging from the median dorsal line of the cotyledons; it is intruded between the cotyledons; embryo with a marked mucro formed by the radicle, cotyledons plano-convex, distinctly separated; chalaza long and narrow with wavy margins (Pl. VI, fig. 24), overlying the line of meeting of the free margins of the cotyledons, extending for two-thirds of the length of the seed on each side and passing around the base. Length of seed, 13 mm.; breadth, 10 mm.; length of embryo imperfect; breadth, 8 mm.

REMARKS.—Fourteen specimens, of which some are fragmentary. The fruits are usually much abraded so that the epicarp and part of the coat within are destroyed. Consequently the layer of branching and anastomosing fibres is frequently exposed at the surface, although usually hidden by parenchyma and stellate cell-groups, at least in the lower half of the fruit. We do not know how much of the thickness of the carpel wall constitutes the endocarp and how much is mesocarp. The embryo is usually much shrunken, the intervening space between it and the unshrunken testa being filled with pyrites.

The specimens were so difficult to distinguish from pieces of rolled wood that we were obliged to fracture them before we could satisfy ourselves as to their true nature. It was only fracture that showed *B. Bowerbanki*, the species next to be described, to be distinct from *B. pyriformis*. Externally they may be almost identical.

AFFINITIES.—There can be no doubt that the fossils belong to the Lauraceae. The size, form, stellate groups of cells, and thin intermittent columnar layer of the endocarp suggest *Beilschmiedia* or *Endiandra*. The distinctly separated cotyledons, and elongate chalaza, with wavy margins, occur in several genera, *e.g. Cryptocarya, Umbellularia, Beilschmiedia*, although in the majority of the Lauraceae the edges of the cotyledons are closely appressed and the chalaza is a circular scar. But the prominent radicle forming a sharp mucro, the narrow chalaza with sinuous margins, the intrusion of the testa between the cotyledons, and the divergence of the lining cells of the testa from the middle of the dorsal surface of the cotyledons, all point to *Beilschmiedia*.

V. 22300 Holotype, figured Pl. VI, figs. 23, 24. A fruit, fractured obliquely in a longitudinal direction (half is missing), showing the character of the embryo, the coats of the carpel wall, and the general form of the fruit and seed.

V. 22301 Figured Pl. VI, fig. 25. A fruit, fractured longitudinally. It shows the general form and size of the seed.

V. 22302 Twelve specimens, all fractured to establish their identity; some imperfect.

All are from the Bowerbank Coll., Sheppey.

Beilschmiedia Bowerbanki n. sp.

PLATE VI, figs. 26–28.

DIAGNOSIS.—Fruit a one-loculed, one-seeded, obovoid berry. Carpel wall formed of two coats: a thick outer coat (about 5 mm. thick) formed of stellate groups of cells, a thin inner coat (endocarp, 0·1 mm. thick) of columnar cells. Testa about 0·8 mm. thick formed of parenchyma with small secreting cells. Breadth of seed about half its length. Embryo with long and slender radicle, chalaza ligulate with wavy margins; cotyledons with tegmen intruded between them.

HOLOTYPE.—V. 22303.

DESCRIPTION.—*Fruit:* A one-loculed, one-seeded, obovoid berry without cupule. Epicarp abraded. The carpel wall (as preserved) is formed of two coats. The thick outer coat (mesocarp or endocarp ?) is formed of closely compacted stellate groups of cells which, on the whole, are smaller than those in *B. pyriformis;* they usually measure about 0·5 mm. in diameter. The thickness of this coat is about 5 mm. It is traversed about 1 mm. from its periphery by a conspicuous system of branching and anastomosing longitudinal fibres, exterior to which the stellate groups of cells are fewer and are interspersed with irregularly arranged parenchyma, whilst within them the irregular parenchyma has almost disappeared and the stellate groups lie very closely packed. The coat described above is immediately followed by a second coat of cells with columnar arrangement (endocarp ?), 0·1 mm. thick. Length of fruit, 26 mm.; breadth, 18 mm.

Seed: Exalbuminous, pointed-ovoid, narrower than that of *B. pyriformis*. The testa (about 0·8 mm. thick) is formed of fine close parenchyma, throughout which are scattered small globular secreting (?) cells about 0·05 mm. in diameter. The tegmen, as in *B. pyriformis*, is formed of small oblong cells placed end to end which form striations diverging from the median dorsal line of the cotyledons. The cotyledons are large, plano-convex, with the tegmen intruded between them. The radicle is long and slender (Pl. VI, figs. 27, 28). The chalaza, as in *B. pyriformis*, forms a band with wavy margins which extends around the base of the seed and along the junction of the cotyledons for about two-thirds of their length (Pl. VI, figs. 27, 28). Length of locule (virtually of seed), 14 mm.; breadth, 8·5 mm.; length of embryo (internal cast of seed), 12 mm.; breadth, 6·5 mm. (measured across the line of junction of the two cotyledons); breadth of one cotyledon, about 5 mm.

AFFINITIES.—One specimen, undoubtedly a *Beilschmiedia*, and close to *B. pyriformis*. However, the absence of a parenchymatous coat between the columnar layer and the stellate groups of cells, the finer, closer, character of the latter, and the more slender seed, all point to the necessity of placing this fruit in a different species.

V. 22303 Holotype, figured Pl. VI, figs. 26–28. A fruit, fractured longitudinally, showing the character of the coats, and the form of the seed and embryo. *Bowerbank Coll.*, Sheppey.

Beilschmiedia eocenica n. sp.

PLATE VI, figs. 29–31.

DIAGNOSIS.—Berry ovoid, about 26 mm. long; carpel wall of two coats (epicarp abraded), an outer coat of large cells arranged in stellate groups with thick fibres embedded towards the periphery, an inner, apparently intermittent, coat (0·06 or 0·07 mm. thick) of cells arranged in a columnar manner. Embryo with small apiculate radicle; chalaza elongate with coarsely sinuous margins.

HOLOTYPE.—V. 22304.

DESCRIPTION.—*Fruit:* Ovoid, soft or leathery ? (always distorted), one-loculed, one-seeded. Carpel wall formed of two coats (as preserved, the epicarp is abraded). The outer coat is thick and formed of large cells arranged in stellate clusters, sometimes 1 mm. or more in diameter, an arrangement seen both in surface view and in section; near to but not at the periphery there are thick strands of fibres. The inner coat, about 0·06 or 0·07 mm. thick, is formed of cells with a columnar arrangement as seen in section, and appears to be intermittent. Length of fruit, about 26 mm.; diameter, about 20 to 24 mm.; thickness of carpel wall, about 4 mm.

Seed: Exalbuminous, ovoid, slightly apiculate at the small radicle (Pl. VI, fig. 31), cotyledons plano-convex; chalaza conspicuous, elongate, extending around the base and on both sides of the seed almost to the radicle, narrow with boldly sinuous margins (Pl. VI, fig. 30). Testa thick (structure somewhat difficult to distinguish); the outer part seems to be formed of large irregularly arranged parenchyma (cells sometimes 0·1 mm. in diameter); next follows a coat several layers thick of smaller cells aligned in rows and forming a smooth surface, the alignment of the cells in successive layers being different; within follows a coat of parenchyma (the cells from 0·025 to 0·05 mm. in diameter). The tegmen is formed of long flat cells which diverge from the margin of the chalaza. Length of a seed, 20 mm.; diameter, about 18 mm.

REMARKS.—Six fruits. In every case the degree of distortion affords clear evidence that the fruit was soft, so that it readily yielded to pressure. In all specimens the pericarp is more or less worn and broken and the seed exposed. Usually the best preserved or exposed coat is the smooth striate layer of the testa, which intervenes between the coarse parenchyma of the outer and the parenchyma of the inner coat. The coarse parenchyma is generally worn away except around the margins of the areas where the striate coat is exposed; the inner finer parenchyma only appears when the smooth surface is itself worn or broken. All the specimens show a very distinct furrow between the cotyledons. The columnar wall of the endocarp, besides being intermittent, is so thin, that it is only with great difficulty, and in small patches, that it can be distinguished.

AFFINITIES.—The succession of coats and the arrangement of the organs in this one-loculed, one-seeded fruit, place it definitely in the Lauraceae. The combination of characters is typical of *Beilschmiedia*.

V. 22304 Holotype, figured Pl. VI, figs. 29–31. A berry, somewhat abraded and broken so as to expose the seed. The cotyledons with sinuous outlines are clearly seen, as is the elongate chalaza with a simple lobed termination at one end and a several-lobed termination at the other.

V. 22305 A berry, abraded over the attachment so as to expose the free ends of the cotyledons and the chalaza.

V. 22306 Three fruits, all more or less abraded or broken so as partly to expose the cotyledons.

V. 22307 A fruit which may belong to this species, broken to expose part of the seed.

All are from the Bowerbank Coll., Sheppey.

Beilschmiedia gigantea n. sp.

Plate VI, fig. 32.

1879. *? Asterocaryum Europaeum* Ettingshausen (pars), p. 393.

Diagnosis.—Berry ovoid, about 39 mm. long. Carpel wall (as preserved, about 3 mm. thick) with cells arranged in stellate groups (sometimes as much as 1 or 2 mm. in diameter). Seed ovoid; chalaza strap-shaped, so far as is known; testa thin; tegmen apparently intruded between the cotyledons.

Holotype.—V. 22308.

Description.—*Fruit:* A large, ovoid, one-celled, one-seeded berry. Surface much abraded, as preserved very rugged. Carpel formed of fusiform or polygonal cells arranged in large stellate clusters (some 1 or 2 mm. in diameter) which are conspicuous both in section and in surface view, especially on the inner surface. Columnar coat not seen; it may be represented, together with the testa, by a thin carbonaceous film lying between the coat above described and the internal cast of the seed. It must in any case have been thin and probably intermittent. Length of berry as preserved, 39 mm.; transverse diameters (distorted), 29 and 34 mm.; thickness of carpel wall, about 3 mm. Another large specimen, which may belong also to the species, measured 42 mm. in length, 30 mm. in diameter.

Seed: Exalbuminous, ovoid, with plano-convex cotyledons (Pl. VI, fig. 32). Chalaza strap-shaped, lying along a deep cleft between the adjacent edges of the cotyledons. Testa very thin, too decayed to afford much information as to the succession of the coats, but there is evidence of a parenchymatous coat overlying a striate fine-celled coat (tegmen ?) seen as an impression on the internal cast of the seed. The striae diverge from the long, narrow chalaza. The coat seems to have been intruded between the cotyledons. Since a portion only of a seed has been seen, the exact dimensions cannot be given, nor the extent of the elongate chalaza.

Remarks.—Three fruits, one of which is rather doubtful. When first recognized they were in fragments, but when pieced together they proved to be almost complete but much abraded specimens. All show the same rugged surface due to differential decay and abrasion. The largest specimen was in a jar with other different lauraceous fruits (since decayed), labelled by Ettingshausen "*Asterocaryum Europaeum*." This specimen certainly belongs to the Lauraceae, and its size and form, as well as the structure of the thick carpel with its stellate groups of cells, all suggest that it belongs to this species, although the evidence is insufficient to place it there with certainty.

Affinities.—The form of this large, one-loculed, one-seeded fruit, the structure of the endocarp, the large plano-convex cotyledons separated by a distinct cleft into which the tegmen is intruded, and the strap-shaped chalaza lying along the junction of the cotyledons, make it clear beyond doubt that this fossil should be referred to Lauraceae. The great size, the stellate structure of the carpel wall, the thin testa, the tegmen intruded between the cotyledons, and the form of the chalaza indicate that it must belong to *Beilschmiedia*.

V. 22308 Holotype, figured Pl. VI, fig. 32. A berry, with part of the carpel wall preserved. The seed is partly exposed, the two cotyledons and part of the chalaza being clearly visible. The specimen is broken.

V. 22309 A berry, with part of the carpel wall preserved; the style and placenta are clearly indicated as a small knob-like prominence. Much distorted and broken.

V. 22310 A large fruit, in fragments. Labelled by Ettingshausen "*Asterocaryum Europaeum.*" It probably belongs to this species, but the seed has not been seen.

All are from the Bowerbank Coll., Sheppey.

Beilschmiedia ? (or *Endiandra ?*) *crassicuta* n. sp.

Plate VI, figs. 33, 34.

1879. *?Juglans eocenica* Ettingshausen (pars), p. 394.

Diagnosis.—Fruit sub-globular; carpel (as preserved) formed of two coats, the outer (about 4 or 5 mm. thick) formed of stellate clusters of cells, the inner (0·1 mm. thick) intermittent and columnar. Seed conical-ovoid; testa (2 or 3 mm. thick) formed of coarse parenchyma; tegmen formed of small polygonal cells which radiate from the micropyle.

Holotype.—V. 22311.

Description.—*Fruit:* A one-loculed, one-seeded berry, sub-globular (the original form somewhat masked by abrasion and distortion), carpel wall thick, formed of two coats (as preserved, the epicarp being abraded), the outer coat (4 or 5 mm. thick) formed of large cells arranged in stellate clusters, each cluster (0·7 or 0·8 mm. in diameter) having a black carbonaceous central group of small cells which are frequently more or less decayed; the inner coat (0·1 mm. thick) intermittent and columnar as seen in radial sections of the fruit. Length of fruit (imperfect at the apex), 22 mm.; diameter, 30 mm. Length of a pear-shaped specimen doubtfully referable to this species, 34 mm.; diameter, 22 mm.

Seed: Conical-ovoid, micropyle at the pointed end. Testa 2 to 3 mm. thick, formed of coarse parenchyma, the outlines of the cells being difficult to trace as they are much obscured by the pyrites with which the coat is heavily impregnated. Tegmen formed of small polygonal cells which radiate from the micropyle; they are seen on the seed-cast. Cotyledons and chalaza not seen. Length of seed, 16·5 mm.; diameter, 19·5 mm. Length of an internal cast of a seed, 14 mm.; diameter, 11 mm.

Remarks.—Two fruits only can definitely be referred to this species; but a pear-shaped specimen, half of which only is preserved, and another fruit labelled by Ettingshausen "*Juglans eocenica,*" may also belong to it. The holotype is much worn, especially at the apex, so that the seed-cast, partly covered by the testa, protrudes (Pl. VI, figs. 33, 34). In the second specimen the lower half of the fruit wall is worn away, exposing the columnar layer covered by a thin film of pyrites with the impression of stellate cell-groups of the outer coat. Isolated seeds or seed-casts have not been seen, hence our knowledge of the seed is imperfect.

Affinities.—The shape and size of the fruit, the thick carpel wall with its stellate cell-clusters, and the intermittent columnar coat within, undoubtedly place these fruits in the family Lauraceae. Similar coats occur in *Endiandra* and

Beilschmiedia and possibly they also occur in other genera which we have not been able to study so closely. The testa in the fossil species is unusually thick. We have not seen a strap-shaped chalaza such as occurs in *Beilschmiedia*, nor have we seen any evidence to suggest that a prolongation of the testa was intruded between the cotyledons. There is also no evidence of a conspicuous prominent radicle. The apparent absence of these characters may be actual fact, in which case the fossils should not be referred to *Beilschmiedia*, or it may be due to fossilization only, in which case the reference to *Beilschmiedia* may be correct. We have not seen a circular basal chalaza in the fossils such as characterizes the genus *Endiandra*, but its apparent absence may again be due to fossilization. The relationship must therefore be regarded as uncertain.

V. 22311 Holotype, figured Pl. VI, figs. 33, 34. A fruit, abraded, especially at the apex. Fractured longitudinally so as to expose the seed, testa, and carpel wall.

V. 22312 A fruit, much abraded, especially over the lower half, where the columnar layer of the carpellary wall is all but exposed at the surface.

V. 22313 Half a pear-shaped fruit, broken into two pieces, which may belong to this species. The testa is not properly seen, nor the character of seed and embryo.

V. 22314 Specimen labelled by Ettingshausen "*Juglans eocenica*," with fruits belonging to other families. The outer coats are almost entirely abraded, only a few layers of cells of the coat with radiating stellate cell-clusters remain adhering to the columnar coat. The testa is preserved. The specimen appears to have been rubbed down transversely in order to expose a cross-section, hence only the radicular end is still extant. No doubt the curious contraction of the seed, producing the effect of incomplete septa, suggested to Ettingshausen a possible relationship to Juglandaceae.

All are from the Bowerbank Coll., Sheppey.

Beilschmiedia ? (or *Endiandra ?*) *fibrosa* n. sp.

Plate VII, figs. 1, 2.

Diagnosis.—Berry ovoid (about 16 mm. long); carpellary coats two, the outer formed of stellate groups of cells (some 0·5 mm. in diameter) with a coarse network of fibres embedded near its periphery; the inner (about 0·1 mm. thick) columnar. Seed with thick testa formed of compact parenchyma; tegmen striate.

Holotype.—V. 22315.

Description.—*Fruit:* An ovoid, one-loculed, one-seeded berry; carpellary coats two; the outer formed of cells arranged in stellate clusters (some 0·5 mm. in diameter) which are seen in surface view and in sections of the wall, a coarse network, formed by branching and anastomosing fibres, which seem to have covered the whole fruit, is embedded near its periphery; the inner (0·1 mm. thick) formed of small cells, is compact, columnar in section, and has well-defined surfaces. At the apex a portion of the aperture of the funicular canal is exposed. Length of fruit, 16 mm.; diameter, 14 mm.

Seed: Sub-globular but evidently much shrunken. Testa thick, formed of compacted parenchyma, internal surface finely striate.

Remarks.—One fruit, perfect except that surface abrasion has resulted in the exposure of part of the network of fibres described above. The fruit was sectioned, but the character and position of chalaza and micropyle were not revealed;

the large seed was found occupying an excentric position in the pyritized locule-cast, being closely approximated to the placental end. The seed itself is hollow; small fragments of the carbonized testa, though too small to give any evidence as to the various organs, furnished information regarding the cells of the testa.

AFFINITIES.—The form of the fruit, the structure of the carpel wall, and the attachment of the seed, all definitely indicate an alliance with Lauraceae. The carpel wall is almost identical in structure with that of a specimen in Kew Herbarium labelled "*Beilschmiedia sphaerocarpa*," collected in Malaya. The fruit of the living species, too, is almost identical in size with the fossil, but is more globular. As the structure of the carpel in *Endiandra* is similar, and there is no evidence available as to the character of the chalaza which in itself serves to distinguish *Beilschmiedia* from *Endiandra*, we cannot be certain to which genus the fossil should be referred.

V. 22315 Holotype, figured Pl. VII, figs. 1, 2. A fruit, fractured to show the character of the seed and of the carpellary coats. *Bowerbank Coll.*, Sheppey.

Genus PROTORAVENSARA nov.

DIAGNOSIS.—Berry ovoid or conical, pointed at the apex, gently convex or flat at the base, with seven (or eight?) longitudinal lobes separated by narrow clefts which penetrate almost to the centre. Primary lobes sometimes subdivided by shallower grooves. Carpel wall formed externally of longitudinal fibres, internally of a columnar coat, about 0·1 mm. thick. Seed agreeing in shape with the locule, external chalaza, covering the flat or convex base of the seed, indented at the margin in accordance with the lobings of the seed; testa fibrous.

GENOTYPE.—*P. sheppeyensis* n. sp.

Protoravensara sheppeyensis n. sp.

PLATE VII, figs. 3–5.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22316.

DESCRIPTION.—*Fruit:* Ovoid or conical, pointed at the apex, usually gently convex or flat at the base, one-loculed, one-seeded, with seven (or eight?) conspicuous longitudinal lobes or segments (Pl. VII, figs. 3, 5), separated by as many deep narrow clefts which extend from base to apex and penetrate almost to the centre. Some of the principal lobes may again be divided into secondary ones by shallower grooves which do not penetrate to the centre. It is difficult to distinguish between primary and secondary lobes except in transverse sections. The carpellary coats (as preserved) are an outer coat formed of thick longitudinal fibres, and an inner thin coat, showing well-defined surfaces formed of cells (0·03 to 0·05 mm. in diameter) polygonal in surface view and with columnar arrangement as seen in sections of the fruit; the latter coat probably represents the endocarp. The surface of the locule is rugose, the rugosities sometimes being transverse, sometimes forming shallow trapezoidal depressions. Length of longitudinally compressed fruit, 7 mm.; diameter, 14 mm. Second specimen (also distorted), length, 16 mm.; breadth, 13·5 mm.

Seed: Lobed in conformity with the locule; chalaza large, almost covering the flat or convex end of the seed, indented at its margin in conformity with the lobing (Pl. VII, fig. 4). Testa formed of two coats; the outer formed of fibres which within the grooves near the chalazal end are directed obliquely, but elsewhere, more especially at the apical prominence which probably indicates the micropyle, are directed longitudinally. The inner surface of this coat is smooth and shining. Within it there is a second thin coat formed of transversely directed fibres or cells; it also has a smooth shining internal surface. The cells over the chalazal area are fusiform and variously aligned so as to present a very confused pattern.

REMARKS.—Four fruits, all somewhat distorted. The fruit which best shows the original conical form is compressed from top to bottom. A second fruit is compressed laterally, and a third obliquely. The succession of the coats in reference to the form is best seen in V. 22316. It shows very clearly: (1) The black columnar endocarp, preserved only in the narrow clefts between the lobes. (2) The coat of longitudinal fibres which forms the testa, represented for the most part by its smooth internal cast. (3) The layer of transverse fibres, or its smooth internal cast. This layer is only seen where layer (2) has been chipped away. The specimen also shows the large irregular cells over the chalazal region. One of the specimens was ground down in order to obtain a transverse section. In the section the columnar endocarp can be traced into the clefts, which are completely lined by it, indicating that the fruit was unilocular and deeply lobed, not multilocular and syncarpous as its appearance at first sight suggests. The fibrous testa can also be seen lying within the columnar endocarp and, like it, curving round the surface of the clefts. V. 22317 shows the thick fibrous coat outside the columnar endocarp. The chalazal end is much worn so as to expose the pyrites filling the seed-cavity. At the apex a small, rounded-conical protuberance raised on a triangular area is probably associated with the micropyle or perhaps with the placenta (Pl. VII, fig. 5).

AFFINITIES.—The fruits are remarkable on account of the deep lobing of the endocarp and seed. The only lobed fruits which we have discovered that are in any way comparable are *Ptychopetalum* Benth. (Icacinaceae), *Henslowia* Blume (Santalaceae), and *Ravensara* Sonnerat (Lauraceae). The first and last of these are six-partite, the second is five-partite with many subsidiary lobes or nodules formed by transverse as well as longitudinal indentations. Neither *Ptychopetalum* nor *Henslowia* shows any relation in structure or shape to the fossil, except that they are one-loculed, one-seeded, lobed fruits; but in both these living genera the lobes are much shallower than in the fossil, and the fruits of *Henslowia* are much smaller. With *Ravensara,* on the contrary, the fossil does show relationship. It is the same size, has the same conical shape with broad base and pointed apex, and the character of the lobes is the same although the number is different. Here the similarity with *Ravensara,* so far as we have been able directly to observe it, ends, but there is this further association: the columnar endocarp in the fossil is definitely such as occurs in numberless Lauraceae, although we have not seen it in *Ravensara.* The longitudinally striate testa, too, is similar to what we have occasionally found in the family. A large basal chalaza is characteristic of the majority of the members of the Lauraceae, while a conical apex is also common. The form of the endocarp and seed of *Ravensara*, when considered in relation to the Lauraceae in general, make it almost certain that the chalaza would occupy exactly the same position and area as it does in the fossil, although owing to scarcity of living material we have not been able to test the correctness of this inference. The evidence so far as it is available suggests that the fossil, although not identical with *Ravensara*, must belong to some closely allied genus. We have therefore named it *Protoravensara sheppeyensis*.

The living genus *Ravensara* is now confined to Madagascar.

V. 22316 Holotype, figured Pl. VII, figs. 3, 4. A fruit, somewhat compressed so that the base appears abnormally flattened.

V. 22317 Figured Pl. VII, fig. 5. A fruit, less distorted than the holotype. The chalazal area is worn or broken ; the endocarp is beautifully preserved.

V. 22318 A fruit, now broken and rubbed down to expose a section through the lobes, which shows the unilocular character.

All the above are from the Bowerbank Coll., Sheppey.

V. 22319 A worn fruit, much encrusted with pyrites, showing the ovoid form, and the internal cast of the endocarp, the polygonal outlines of the endocarp cells being reproduced clearly on the cast. Remains of the endocarp and of the seed are also clearly preserved. *D. J. Jenkins Coll.*, Herne Bay.

Genus CROWELLA nov.

DIAGNOSIS.—Fruit enclosed almost completely in a thick cupule formed by the imperfectly fused perianth segments, seated on the swollen peduncle ; sub-globular ; mesocarp formed of close-textured parenchyma with secreting cells, endocarp columnar, 0·05 mm. thick. Seed sub-globular, narrowed towards the base and apex, chalaza circular, occupying about a third of the length of the fruit. Testa coarse-celled, secreting.

GENOTYPE.—*Cupressinites globosus* Bowerbank.

Crowella globosa (Bowerbank)

PLATE VII, figs. 6–11.

1840. *Cupressinites globosus* Bowerbank, p. 52, pl. x, figs. 12–14, 32, 33.
1840. *Cupressinites elongatus* Bowerbank, p. 54, pl. x, figs. 15–18.
1840. *Cupressinites recurvatus* Bowerbank, p. 55, pl. x, fig. 19.
1845. *Cupressites globosus* (Bowerbank) Unger, p. 192.
1845. *Cupressites elongatus* (Bowerbank) Unger, p. 192.
1845. *Cupressites recurvatus* (Bowerbank) Unger, p. 192.
1847. *Actinostrobites globosus* (Bowerbank) Endlicher, p. 9.
1847. *Actinostrobites elongatus* (Bowerbank) Endlicher, p. 9.
1847. *Frenelites recurvatus* (Bowerbank) Endlicher, p. 9.
1850. *Actinostrobites globosus* (Bowerbank) : Unger, p. 344.
1850. *Actinostrobites elongatus* (Bowerbank) : Unger, p. 344.
1850. *Frenelites recurvatus* (Bowerbank) : Unger, p. 344.
1879. *Cupressinites globosus* Bowerbank : Ettingshausen, p. 392.
1879. *Cupressinites elongatus* Bowerbank : Ettingshausen, p. 392.
1879. *Cupressinites recurvatus* Bowerbank : Ettingshausen, p. 392.

Diagnosis.—That of the genus.

Holotype.—V. 22320.

Description.—*Fruit:* Superior, a berry enclosed almost to the apex by a thick cupule which is seated on, fused with, and to a very slight degree enclosed by an enlarged obconic receptacle, the junction of fruit and receptacle being marked by a circular rim.

Cupule: Formed by the fusion of the enlarged, persistent, segments of the perianth (Pl. VII, figs. 6, 8, 9); the segments are fused on their inner faces, free on their outer, 6-merous, arranged in two whorls; the outer segments large, ovate, approximating to, but not meeting one another, along their lateral margins (Pl. VII, figs. 6, 7, 9); the inner segments, alternating with the last, narrow, linear or spathulate, sub-acuminate (Pl. VII, figs. 6, 9). In one small specimen (Pl. VII, fig. 9), probably immature (V. 22320, figured Bowerbank, 1840, pl. x, figs. 32, 33), within and opposite to the tips of the broad segments, are three small tumidities covered by the same epidermal cells as the segments themselves, which may represent either a whorl of staminodes, or, more probably, the free tips of the large perianth lobes which have been bent inwards and partially buried in pyrites. The epidermis over the whole surface of the cupule is formed of small polygonal cells (0·016 mm. in diameter) which produce a delicate tessellated surface. The wall of the cupule is formed of fairly coarse parenchyma within which are embedded a few longitudinal strands of fibres rather difficult to expose. It is thick at the base but thins towards the apex. It is not fused with the berry, as is indicated by a layer of pyrites which has infiltrated between the two. Length of fruit in cupule, 12·5 to 17 mm.; diameter, 13 to 17 mm. Length of stalk or base of cupule (as preserved), 5·5 mm.; maximum breadth, 11 mm. Length of (?) immature fruit, 11 mm.; diameter, 10 mm.

Berry: Sub-globular, one-loculed, one-seeded, narrowed towards the attachment and apex (Pl. VII, figs. 10, 11). Pericarp formed of three coats, a smooth shining epicarp (about 0·05 mm. thick) formed of a single layer of close-set polygonal cells (very difficult to measure, but apparently about 0·016 mm. in diameter) which present a columnar appearance as seen in radial sections of the cupule; a pulpy (?) mesocarp formed of small loose-textured parenchyma within which are many globular bodies (oil-cells?); a hard, woody endocarp (0·2 mm. thick) formed of about five layers of large cells (difficult to measure, but about 0·016 to 0·025 mm. in diameter) with extremely tortuous outlines as seen in surface view, and with a columnar arrangement as seen in radial section (Pl. VII, fig. 11). The seed is pendulous from the apex of the endocarp.

Seed: Sub-globular, narrowed towards the base and apex, anatropous, hilum near the apex of the fruit, raphe lateral, chalaza large, circular, occupying about a third of the seed, at the end which is opposite the hilum and turned towards the base of the fruit. Testa more or less fused with the endocarp except over the chalaza; the outer coat loose-textured, formed of large, square or polygonal cells often as much as 0·15 mm. in diameter, which appear to have contained some secretion now represented by a shining black substance or by glittering pyrites; the inner coat smooth, formed of small angular cells. Length of seed, 7 to 8 mm.; breadth, 6 to 8 mm. It approximates closely in size to the endocarp, which is only slightly larger.

REMARKS.—Twelve specimens, and fragments of a thirteenth. All show the perianth segments more or less clearly, and some show the swollen peduncle. When the cupule and floral envelopes are perfectly preserved, the specimens present something of the appearance of a three-carpelled fruit seated in a cupule (Pl. VII, fig. 6). When the outer floral envelope has gaped so that the inner perianth segments appear, the fruit might be mistaken for a loculicidal or three-valved capsule of which the centre has become filled with pyrites. It is possible that these inner perianth segments are only seen clearly in immature fruits, as the specimen in which they appear most distinct is small, and shows no indications of a ripe berry (V. 22320). In ripe specimens the apex of the berry appears between the gaping perianth segments. In worn specimens the perianth segments, carpellary coats and testa may all be abraded in a greater or lesser degree so that in some specimens, within the remains of the cupule one or another of the carpellary coats may be exposed, or the testa with fragments of the carpel adhering to it, or even the inner coat of the testa alone. The appearance changes according to the degree of abrasion.

AFFINITIES.—Some of these specimens were described by Bowerbank as *Cupressinites globosus*. He evidently regarded them as three-scaled cones. But, since no cones of the Coniferae show integuments resembling those of the fossil, nor have any so large a number of integuments, we have had to reject any relationship to the Coniferae. The structure of berry and seed, especially as seen in section, leaves no doubt that the specimens belong to the family Lauraceae, and to a genus in which the berry is almost entirely enclosed in a persistent cupule, formed at the base by the swollen stalk or receptacle and above by the enlarged perianth segments. Although persistent free perianth segments are common in the Lauraceae, *e.g.* *Cinnamomum* Blume, *Cassytha* Linn., we have seen no living genus in which they are so large or in which, while they retain their individuality externally, they are fused internally. We have therefore renamed the specimens *Crowella* in honour of Francis Crow, who first illustrated the species in his manuscript catalogue (1810, No. 218), and have united Bowerbank's species *Cupressinites globosus*, *C. elongatus*, and *C. recurvatus* as one, under the name *Crowella globosa*. *C. recurvatus* appears to have been a well-preserved, relatively unworn specimen.

It is interesting to notice that Gardner (1883, p. 20) had previously rejected Bowerbank's reference of the fossils to Cupressineae on account of the unlikeness of structure, although he considered that *C. recurvatus* and one specimen only of *C. globosus* (figured Bowerbank, 1840, pl. x, fig. 14) might possibly be referable to *Callitris*. He also stated that *C. elongatus* was identical with *C. globosus*.

V. 22320 Holotype, figured Pl. VII, fig. 9. Also figured Bowerbank (1840, pl. x, figs. 32, 33). A small fruit, with cupule perfectly preserved.
V. 22321 Figured Pl. VII, figs. 6–8. A fruit, showing cupule, epicarp, mesocarp, and endocarp.
V. 22322 Figured Pl. VII, figs. 10, 11. A fruit, fractured to show the structure of cupule, berry, endocarp, and seed.
V. 22323 A cupule, worn at the top to expose the apex of the berry.

V. 22324 A fruit, fractured to show the seed and the contraction over the chalaza scar.
V. 22325 Seven fruits, some fractured, and fragments of an eighth.
All are from the Bowerbank Coll., Sheppey.

Genus LAUROCALYX nov.

Diagnosis.—Cupuliferous fruits belonging to the family Lauraceae which, for one cause or another, cannot be referred to living genera.

Laurocalyx globularis n. sp.

Plate VII, figs. 12–15.

Diagnosis.—Cupule almost entirely (? entirely) enclosing the berry. Berry globular, with mesocarp formed of small radially compressed cells, endocarp (0·22 mm. thick) of cells, as seen superficially, elongate longitudinally and with straight outlines, in radial sections, columnar. Seed conical-globular, conical at the hilar end; chalaza (5·5 mm. in diameter) occupying one-sixth the length of the seed, at the broad end; testa with a single layer of secreting cells which have tortuous outlines. Diameter of cupule, 12 mm.

Holotype.—V. 22326.

Description.—*Fruit:* A one-loculed, one-seeded berry enclosed almost entirely (or entirely ?) in a cupule. Length as preserved, 9·5 mm.; diameter, 12 mm.

Cupule: (Formed by the enlarged receptacle ?). Having at its base a scar with very sinuous margins which is certainly the scar of attachment of a stalk; the walls are thick at the base and gradually become thinner towards the apex (which has unfortunately been broken so that it must remain conjectural whether or not the cupule completely enveloped the berry); they are formed of rather loose-textured, fine parenchyma, within which are embedded longitudinal strands of fibres.

Berry: The pericarp is now fused with the cupule, but part of the fusion may be due to the infiltration of a cement of pyrites. Three layers can be distinguished: (1) A thin columnar epicarp (0·05 mm. thick, or less) formed of small cells not easy to measure. (2) A thicker mesocarp of many layers of small polygonal cells much compressed radially. (3) An endocarp (0·22 mm. thick) of small cells (0·035 to 0·05 mm. in diameter) with a columnar arrangement as seen in radial sections of the fruit, but longitudinally elongate as seen in surface view, and with straight, not sinuous, outlines. The seed is pendulous from the apex of the locule.

Seed: Sub-conical, pointed at the hilar end (*i.e.* at the end towards the apex of the fruit); anatropous, with the hilum at the narrow end and the chalaza, which occupies one-sixth the length of the seed and is 5·5 mm. in diameter, at the broad end; micropyle apical at the narrow end; testa formed of three coats, the outer of these consists of a single layer of large secreting cells, with highly tortuous outlines, within which are two delicate, almost diaphanous layers; the one formed of large, parallel-sided elongate cells aligned longitudinally, either tapering or truncate at their ends; the other of much smaller cells aligned in transverse rows especially around the micropyle, where they form a series of fine concentric rings. It is impossible to tell which of these two layers is the outer. Length of seed, 7 mm.; diameter, 7·4 mm.

REMARKS.—One fruit (imperfect at the apex). A second specimen may perhaps belong to this species, but its relationship is very doubtful. The type specimen was fractured in order to determine its nature, which was not apparent from the exterior.

AFFINITIES.—The fruit undoubtedly belongs to the Lauraceae, as evidenced by the structure of cupule, pericarp, and seed. The fact that the cupule almost entirely enveloped the nut suggested a possible relationship with *Cryptocarya* R. Br. A study of the fruits of this genus at Kew, however, showed that the morphological and microscopic structures of the fossil were not in agreement with those of the living. All those species of *Cryptocarya* which we have had the opportunity of examining in detail show a dark outer integument (cupule ?) apparently formed of parenchyma containing a secretion. In some species, but not in all, this is more or less delimited from the next integument by a definite surface. This next integument (mesocarp ?) which may be thick or thin, is formed of fibres with interbedded parenchyma; sometimes the fibres lie concentric with the periphery, sometimes, when the coat is thick, they are very tortuous and their general direction tends to be radial. Within this is a very thin integument not more than one or two cells thick which seems to represent the endocarp. The testa, so far as we have been able to observe it, is exceptionally thick, hard, and compact. The coats therefore differ from those seen in the fossil in their individual characters. Thus, in the fossil the parenchyma of the cupule is finer, the epicarp is more clearly defined, the mesocarp (?) is formed of parenchyma, and not (if this is the mesocarp) of fibres as in *Cryptocarya*; the endocarp is thicker and more readily distinguished; the testa is much thinner; also, there is a distinction in the form of the seed which may or may not be significant. In those seeds of *Cryptocarya* which we have studied the radicle forms a conspicuous sharp mucro which lies within a conical apical aperture in the pericarp. Although the apex of the fruit is slightly broken in the fossil, so far as it is preserved there is no indication that the seed, though conical at the apex, was ever conspicuously mucronate. We cannot therefore refer the fossil to *Cryptocarya*.

In view of the definite evidence of the presence of a cupule, we have placed the species provisionally in the form-genus *Laurocalyx*, to which we refer lauraceous fruits with cupules whose nearer relationship cannot be determined.

V. 22326 Holotype, figured Pl. VII, figs. 12–15. A fruit, now fractured so that the seed-cast is isolated. The broken remains of the fused cupule and pericarp are preserved. *Bowerbank Coll.*, Sheppey.

V. 22327 A fruit in a cupule, fractured longitudinally. The specimen may belong to this species, but the relationship is extremely doubtful. *Reid & Chandler Coll.*, Minster, 1929.

Laurocalyx fibrotorulosus n. sp.

PLATE VII, figs. 16, 17.

DIAGNOSIS.—Cupule (extent unknown) formed partly of stellate groups of cells. Berry sub-globular, conical above, showing on the endocarp a circular constriction which delimits the scar of attachment (15 mm. in diameter); integuments:

(1) tessellated epicarp, (2) a layer of torulose fibres, (3) several layers of small cells forming a coat 0·2 to 0·25 mm. thick, (4) columnar endocarp formed of cells 0·1 mm. long and 0·025 mm. broad in surface view.

Holotype.—V. 22328.

Description.—*Fruit:* A one-loculed, one-seeded berry enclosed (to what degree is unknown) in a cupule. Length and breadth both incomplete.

Cupule: Very thick where preserved, formed of large cells sometimes arranged in stellate clusters.

Berry: Sub-globular but conical at the apex, showing on the endocarp a large basal circular constriction, 15 mm. in diameter, which delimits the scar of attachment (Pl. VII, fig. 17), and a small apical transverse foramen marking the placenta (Pl. VII, fig. 16). Pericarp consisting of the following coats: (1) the epicarp, which is formed of small polygonal cells, 0·016 mm. in diameter, which give a tessellated shining surface, where this is exposed; (2) a layer (or layers ?) of flat tortuous fibres which give a serpentine surface; (3) a coat, 0·2 to 0·25 mm. thick, formed of several layers of small cells; (4) the columnar endocarp, 0·1 to 0·15 mm. thick, showing in surface view elongate, fusiform, or parallel-sided cells, 0·025 mm. broad, and often 0·1 mm. long, which radiate from the apex of the fruit. Length of locule-cast, 11 mm.; greatest diameter, 19 mm.; least diameter, 11 mm. (The nut is much distorted, hence the variation of diameter.)

Seed: Similar in shape to the locule. Testa very thin, structure obscure. Chalaza, hilum, and micropyle not seen. Dimensions almost identical with those of the locule.

Remarks.—One specimen only. This is a locule-cast to which fragments of the pericarp, as well as a considerable portion of the broken cupule, still adhere. The cast, although broken and distorted, shows the form of the berry, and within its broken surface can be seen scanty remains of the seed. The remains of the cupule, although sufficient to show its structure, give no idea as to the degree in which it enveloped the berry.

Affinities.—The structure of this cupulate fruit leaves no doubt that the specimen belongs to the Lauraceae, but the cupule is too incomplete to suggest what might be its generic relationship. Thinking that it might be related to *Nectandra* Roland, as was rather suggested by the fragment of cupule and the form of the berry, we examined the structure of the berry in this genus, so as to ascertain whether there were a layer of fibres immediately beneath the epicarp. There are many fibres, but these are arranged in bands which give off branches, and are not torulose as in the fossil. Although the fossil species cannot be completely defined, it is so definitely individualized by the presence of the cupule and by the serpentine layer of fibres within the epicarp, that we have given it a specific name, placing it in the form-genus *Laurocalyx* as *L. fibrotorulosus*.

V. 22328 Holotype, figured Pl. VII, figs. 16, 17. An imperfect and fractured fruit. *Bowerbank Coll.*, Sheppey.

Laurocalyx dubius n. sp.

Plate VII, figs. 18, 19.

Diagnosis.—Cupule, cup-shaped, formed of parenchyma; diameter, 19 mm. Berry sub-globular, slightly conical at the apex, 11 mm. in diameter; epicarp, 0·04 mm. thick; mesocarp, 0·25 to 0·3 mm. thick, formed of small flattened cells arranged in radial rows; columnar endocarp, 0·05 to 0·1 mm. thick. Seed sub-globular, conical at the apex; testa formed of two layers of secreting cells, often 0·1 mm. in diameter, and an inner layer (or layers ?) of elongate cells longitudinally aligned.

Holotype.—V. 22329.

Description.—*Fruit:* A berry partly enclosed in an adherent cupule. Length, together with broken cupule, 14 mm.; diameter, 19 mm.

Cupule: Thick, cup-shaped, covering the lower two-thirds of the berry, formed of loose-textured parenchyma within which lie strands of fibres.

Berry: Sub-globular, slightly conical above, one-celled, one-seeded; pericarp formed of three coats: the epicarp (0·04 mm. thick), shining and black, formed of cells 0·025 mm. in diameter, polygonal in surface view, and with a columnar appearance in radial sections of the fruit; mesocarp (0·25 to 0·3 mm. thick), formed of a few layers of small flattened cells which tend to have a radial arrangement; endocarp (0·05 to 0·1 mm. thick) formed of small cells with tortuous, confused, superficial outlines and columnar arrangement as seen in radial sections of the fruit. Length of berry without cupule, 11 mm.; diameter, 11 mm.

Seed: Sub-globular, conical at the hilar end; testa formed of one or two layers of large secreting angular cells of variable size (frequently 0·1 mm. in diameter), followed within by a layer of elongate cells longitudinally aligned; chalaza and raphe not seen; dimensions slightly less than those of the nut, but the seed was not sufficiently exposed for accurate measurement.

Remarks.—A single specimen taken as the type belongs to the Bowerbank Collection, but possibly other specimens should also be referred to the species. The specimen was much broken at the base so that the nut was exposed; the cupule is also worn and incomplete at the top. The fruit wall and cupule, which are very thin, were so decayed that without making a fresh fracture it was impossible to tell whether a worn pericarp alone were represented, or a pericarp and cupule. The fracture was therefore made, and the structures described above were thereby exposed. The presence of the smooth shining black epicarp within the thickness of the wall proved conclusively that the specimen was a berry enclosed in a cupule. The degree to which berry and cupule were fused is shown by a circular scar (Pl. VII, fig. 18).

Affinities.—That the fruit belongs to Lauraceae, there cannot be the slightest doubt, but unfortunately the fragmentary condition of the cupule makes it impossible definitely to trace the generic relationship, although the size of the berry and the character of the cupule, so far as that is known, limit the possible relationship to a very few genera. We have seen comparable cupules in *Ocotea* Aubl. and in *Litsea*

Lam. *O. trichophlebeia* Baker agrees very closely with the fossil in size, and in the shape of the upper part of the cupule, but we have been unable to make closer comparison.

The fossil is distinguished from all other cupular fruits here described by its size, by the form of its cupule, and by its structure. From *Litsea pyriformis* (p. 204) by the shape of its cupule, which cannot, judging by what remains of it, have been pyriform; also by its thin endocarp. From *Crowella globosa* (p. 216) by the absence of separate perianth segments, and again by the thin endocarp. From *Laurocalyx globularis* (p. 219) by the greater size both of berry and cupule.

V. 22329 Holotype, figured Pl. VII, figs. 18, 19. An imperfect fruit; cupule and adhering pericarp fractured. *Bowerbank Coll.*, Sheppey.

Laurocalyx Bowerbanki n. sp.

Plate VII, figs. 20–24.

Diagnosis.—Berry cupulate. Cupule formed of parenchyma, stellate clusters of cells, and a few fibres. Endocarp (all that remains of the berry) conical above, convex below, with a large circular scar of attachment to the cupule constricted at its margin, thickness of wall 0·2 mm., formed of cells with columnar arrangement in section, elongate longitudinally superficially. Seed, the shape of endocarp; testa thin; raphe branching over the chalaza, which is larger than the constricted area of the carpel.

Holotype.—V. 22330.

Description.—*Fruit:* Partially enclosed in a cupule, but there is no evidence to show to what extent, as the specimen is much abraded (Pl. VII, fig. 20).

Cupule: Formed of parenchyma with some stellate clusters of cells and a few embedded fibres, showing a large internal scar of attachment to the berry, 8 mm. in diameter (Pl. VII, fig. 21).

Berry: Represented by the endocarp, sub-globose, conical above, convex below, with a large basal scar of attachment corresponding to that of the cupule (Pl. VII, figs. 22, 23), one-celled, one-seeded, the seed pendulous from the apex; epicarp and mesocarp not distinguishable, but probably represented by a coat of decayed carbonaceous matter which shows an irregular decayed surface; endocarp 0·2 mm. thick with well-defined surfaces, formed of oblong cells (0·016 to 0·05 mm. broad and two or three times as long) longitudinally aligned so as to produce, superficially, longitudinal striae, and with columnar arrangement as seen in radial sections of the berry. Length of endocarp, 13 mm.; diameter, 13 mm.

Seed: Conical above, convex below, anatropous, with the hilum at the narrow end and the chalaza at the broad end, where it occupies more than a third of the length of the seed, its exact limits not being traceable on account of the adhering endocarp and locule-cast, but certainly extending far beyond the limits of the constriction; raphe lateral, thick, and branching freely over the chalaza; testa thin, structure obscure. Length of seed, 11 mm.; diameter, 10 mm.

Remarks and Affinities.—An imperfect fruit (the holotype) and an isolated endocarp. The evidence for describing a cupule lies in the large basal scar to be seen both on the endocarp and on the interior of the thick, broken, cup-like envelope which is all that remains of the cupule and exocarp. If this envelope represented the exocarp only, any scar of attachment would be found on its external surface, not as it actually occurs on the internal surface, as may be seen by comparison with living material. Consequently the envelope must be, in part at least, a cupule. Further evidence is seen in the corresponding scar and circular constriction at the base of the endocarp, such as we have found to be associated with the endocarps of the cupulate fruits of Lauraceae. The substance of the cupule appears to be represented by parenchyma with stellate groups of cells and a few fibres interspersed, and the exocarp by the decayed carbonaceous matter which lies between this and the endocarp. There can be no doubt of the relationship to the Lauraceae nor of the cupulate character of the fruit although the actual extent of the cupule cannot be determined.

V. 22330 Holotype, figured Pl. VII, figs. 20–24. A fruit, with remains of the cupule.
V. 22331 An endocarp.
Both are from the Bowerbank Coll., Sheppey.

Laurocalyx magnus n. sp.

PLATE VII, figs. 25, 26.

DIAGNOSIS.—Fruit completely (?) enclosed in a cupule. Cupule thick, 26 mm. long, showing many stellate groups of cells, and also sub-peripheral fibres. Endocarp conical-globose with wall 0·3 mm. thick, columnar in section, formed in surface view of small oblong or fusiform cells ; funicular aperture mouth-like, circular scar of attachment to cupule delimited by a constriction. Seed similar in shape to the endocarp ; chalaza large, limits not seen.

HOLOTYPE.—V. 22332.

DESCRIPTION.—*Fruit:* A berry, completely (?) enclosed in a cupule.

Cupule: Thick (3·5 mm. near the base), formed of large cells, which tend to aggregate into stellate groups and on decay produce an irregularly abraded surface; near the base and towards the periphery there are many strands of fibres. Length, 26 mm. ; greatest diameter, 30 mm. ; least diameter, 25 mm.

Berry: One-celled, one-seeded, seed pendulous from the apex ; conical-globose (as represented by the endocarp), with a circular scar of attachment to the cupule delimited by a constriction at its base (Pl. VII, fig. 26), and a large mouth-shaped funicular foramen at its apex ; exocarp and mesocarp apparently represented by a much decayed carbonaceous coat between the cupule and endocarp ; endocarp, 0·3 mm. thick, formed of cells which have a columnar arrangement as seen in radial section of the fruit, but in surface view appear as longitudinally aligned, fusiform, or parallel-sided cells (0·025 mm. broad × 0·05 mm. long), giving a striate appearance to the endocarp. Length of endocarp, 20 mm. ; diameter, about 22 mm.

Seed: Corresponding in shape to the endocarp, chalaza large, exact limits not seen, raphe branching over its surface. Testa obscure.

Remarks.—One specimen, with much of the cupule preserved, but broken, and detached from the seed. It appears to have enveloped the fruit almost completely (Pl. VII, fig. 25). A peripheral layer has broken away from the greater part of the base of the cupule thereby exposing the embedded fibres. The inner surface of the cupule shows many stellate groups of cells. The evidence for regarding this thick outer integument as a cupule is furnished by the marked scar, delimited by a circular constriction, at the base of the endocarp (cf. *Laurocalyx Bowerbanki*, p. 223). Such scars can only be accounted for as delimiting the area of fusion of the fruit with the cupule.

Affinities.—The relationship of this specimen to the Lauraceae is clear. It is distinguished by its great size, and especially by the size of the seed, from the other Sheppey species referred to *Laurocalyx*. In these respects it comes nearest to *Laurocalyx fibrotorulosus*, which it also somewhat resembles in the character of the endocarp (p. 220). But it is more conical in shape, and we have seen no indications of the remarkable layer of torulose fibres found beneath the epicarp in that species ; the fibres described in *L. magnus* lie in the peripheral layer of the cupule, not between the epicarp and mesocarp. Also the endocarp in *L. magnus* is thicker than in *L. fibrotorulosus*.

V. 22332 Holotype, figured Pl. VII, figs. 25, 26. A fruit, broken and imperfect. *Bowerbank Coll.*, Sheppey.

Genus LAUROCARPUM nov.

Diagnosis.—One-loculed, one-seeded fruits which have more than one of the diagnostic characters of Lauraceae (see Introduction to Family, p. 195), but which cannot be generically distinguished owing to lack of knowledge of the living or fossil material.

Laurocarpum sheppeyense n. sp.

Plate VII, figs. 27, 28.

1879. *Trinax Bowerbankii* Ettingshausen (pars), p. 393.
1879. *Victoria sheppyensis* Ettingshausen (pars), p. 395.

Diagnosis.—Endocarp one-loculed, one-seeded, with seed pendulous from the apex ; sub-globular, bisymmetric, angled longitudinally in the plane of symmetry, faintly ribbed longitudinally, placenta marked by a large mouth-like depression, formed of small polygonal cells with sinuous walls and columnar arrangement. Seed sub-globular, anatropous, chalaza occupying the lower half of the surface ; testa showing an outer coat of tortuous cells.

Holotype.—V. 22333.

Description.—*Endocarp :* One-loculed, one-seeded, with the seed pendulous from the apex ; sub-globular, but slightly pointed at both ends, bisymmetric, the plane of symmetry being marked by a longitudinal ridge or angle such as in living fruits overlies the raphe on the seed (Pl. VII, fig. 27), placenta marked by a large conspicuous sub-triangular or roundly oblong depression on the locule-cast and seed (the funicular canal and aperture are too much broken and worn to be traced); the wall (0·2 mm. thick) formed of small cells with columnar arrangement as seen in radial sections of the fruit and varying superficially in size and outline, but with very sinuous margins. Diameter of endocarp, 7·5 to 9 mm.

Seed: Sub-globular, anatropous, hilum and micropyle adjacent at one pole, chalaza large and smooth, occupying about half the surface of the seed at the opposite pole (Pl. VII, fig. 28). Testa badly preserved and therefore obscure, having an outer coat of cells with tortuous margins (almost always decayed) and an inner coat of small, polygonal cells, often 0·025 mm. in diameter (seen only in impressions).

REMARKS.—Twenty specimens. The least abraded of these, which gives the clue to the true characters of this species, is V. 22333 (Pl. VII, fig. 27). Some were labelled by Ettingshausen "*Victoria sheppyensis* sp. n." and others "*Trinax Bowerbankii*." The endocarps are usually so abraded that they are only recognizable by the large gaping mouth-like depression described above. Most frequently the endocarp is entirely worn away except near this depression, so that the funicular canal itself is gone. The testa also is invariably much decayed, and the cell outlines are seen only as impressions. There is no evidence preserved of any secretion in the cells of the testa.

AFFINITIES.—The relationship to the family Lauraceae is clearly evidenced by the one-loculed, one-seeded endocarp with columnar wall, by the characteristic placental depression and the large smooth hemispherical chalaza. We have not been able to refer the fossils to a living genus.

V. 22333 Holotype, figured Pl. VII, fig. 27. An internal cast of a seed, showing the characteristic triangular depression associated with the hilum. It also shows the chalaza. *Reid & Chandler Coll.*, Minster, 1929.

V. 22334 Figured Pl. VII, fig. 28. An internal cast of a seed. *Bowerbank Coll.*, Sheppey.

V. 22335 A cast of a seed with a small adherent patch of endocarp beneath a protecting cover of pyrites. *Bowerbank Coll.*, Sheppey.

V. 22336 Ten seeds in various stages of abrasion. *Bowerbank Coll.*, Sheppey.

V. 22337 Seven seeds in various stages of abrasion. *Reid & Chandler Coll.*, Minster.

Laurocarpum paradoxum n. sp.

PLATE VII, figs. 29–34.

1879. *Asterocaryum europaeum* Ettingshausen (pars), p. 393.
1879. *Bactris prisca* Ettingshausen, p. 393.
1879. *Diospyros eocenica* Ettingshausen (pars), p. 394.

DIAGNOSIS.—Endocarp sub-globular, bisymmetric, ridged on one side along the plane of symmetry, with a mouth-like funicular foramen, length 11 to 13 mm.; surface with nodular longitudinal ribs; wall columnar in section, from 0·2 to 0·75 mm. thick. Seed ovoid, conical at the hilar end; chalaza occupying rather over half the surface of the seed; testa with an outer coat of secreting cells.

HOLOTYPE.—V. 22338.

DESCRIPTION.—*Endocarp:* One-loculed, one-seeded, the seed pendulous from the apex, sub-globular, bisymmetric, the plane of symmetry being marked by a longitudinal ridge which arises from the middle of the upper margin of the funicular opening and is sharp at the apex but gradually dies out towards the base; pierced at the apex by a large transverse aperture with thickened rim, through which the funicle enters the locule (Pl. VII, figs. 30, 32) to form the placenta; surface longitudinally ribbed, the ribs being bold and interrupted or nodular (Pl. VII, figs. 29, 31); wall varying in thickness (0·2 mm. over the sides, and as much as 0·75 mm. near the placenta), formed of polygonal cells with sinuous borders, irregular both in size and shape, and with columnar arrangement as seen in radial sections of the fruit. Length, 11 to 13 mm.; diameter, 10 to 11 mm.

Seed: Ovoid or sub-globular, conical at the hilar end (that facing the apex of the fruit), triangularly faceted at the chalazal end, and with a longitudinal ridge which carries the raphe; anatropous, with hilum at the narrow end, raphe lateral in the plane of symmetry but branching and anastomosing freely over the chalaza which occupies more than half the surface of the seed at the end opposite to the hilum, internal chalaza smooth (Pl. VII, fig. 34); testa closely fused with the endocarp except over the chalaza; formed of two coats, the outer of large obscure irregularly-polygonal, elongate, or fusiform cells, the inner (best seen over the chalaza) diaphanous, of quadrate cells varying in size but frequently 0·025 mm. in diameter; embryo exalbuminous; cotyledons large and hemispherical. Length of seed, 8 to 10 mm.; breadth, 6·5 to 8 mm.

Remarks.—At least sixty specimens, and more probably ninety, are referable to this species. The majority belong to the Bowerbank Collection, but one endocarp was collected by Toulmin Smith and eight (either seeds or endocarps) by ourselves. The species is one of the commonest among the London Clay Lauraceae. A few endocarps show perfectly the ribbed and nodular surface. The three best preserved were labelled by Ettingshausen "*Asterocaryum europaeum*" (Pl. VII, figs. 29–31). The ribbing of the surface is probably original, but may have been emphasized by shrinkage. It is constant in character. At least two specimens show very clearly the form of the locule-cast and, as in Lauraceae the seed approximates very closely to the form of the locule, the locule-cast may be taken to represent the seed in form. The longitudinal ridge which carries the raphe lies immediately beneath the corresponding ridge on the endocarp. The casts also show the triangular faceting of the chalazal end. Around the apex of the cast (hilar end of the seed) fragments of the endocarp still remain, adhering closely, the transverse mouth-like aperture for the funicle being preserved in both specimens (Pl. VII, figs. 32, 33). A number of the specimens are the internal casts of seeds showing the internal chalaza, whilst one or two of these show the hemispherical cotyledons.

In addition to the fruits labelled "*Asterocaryum europaeum*," several specimens were labelled "*Bactris prisca*" by Ettingshausen, whilst nine specimens, probably referable to this species, were with other fruits labelled "*Diospyros eocenica*" by Ettingshausen. These nine specimens are chiefly seeds with remains of the endocarp at the hilar end; they retain their globular shape and show clearly the large mouth-shaped aperture for the funicle and the large chalaza.

Affinities.—The relationship to Lauraceae is established beyond a doubt by the structure of the endocarp and seed, which are highly characteristic of the family. The species belongs to one of the smaller fruited Lauraceae such as *Cinnamomum*, *Sassafras*, *Lindera*, *Neolitsea*, and *Litsea*, which have chalazas occupying rather more than half the surface of the seed. We have seen no comparable wrinkled endocarps among living fruits.

V. 22338 Holotype, figured Pl. VII, figs. 29, 30. An endocarp, one of three labelled by Ettingshausen "*Asterocaryum europaeum*."
V. 22339 Figured Pl. VII, fig. 31. A second endocarp labelled as above.
V. 22340 Figured Pl. VII, fig. 32. A seed with remains of the endocarp still adhering around the hilum and placenta.
V. 22341 Figured Pl. VII, fig. 33. A seed in a similar state of preservation, but more smoothed by abrasion than the preceding. *Reid & Chandler Coll.*, Minster, 1929.
V. 22342 Figured Pl. VII, fig. 34. An internal cast of an ovoid seed showing the chalaza and definite indications of the cotyledons.
V. 22343 An internal cast of a seed showing the chalaza. The endocarp is completely abraded even in the hilar region.
V. 22344 An endocarp; the third specimen labelled by Ettingshausen "*Asterocaryum europaeum*."
V. 22345 Half an endocarp, which has been fractured longitudinally. It shows the wall in section, and the overlapping of the wall to form a canal where the section passes through the funicular aperture at the apex.
V. 22346 Four specimens; an endocarp, an endocarp broken to show the seed-cast within, and two internal casts of seeds.
V. 22347 Fifteen specimens with some or all of the endocarp remaining.
V. 22348 Thirty much worn specimens, mainly internal casts of seeds, and a few fragments.
V. 22349 Thirteen specimens, much worn, representing internal casts of lauraceous seeds; some certainly, probably all, belong to this species. Labelled by Ettingshausen "*Bactris prisca* Ett."
V. 22350 Nine abraded seed-casts and a few fragments, probably referable to this species, labelled by Ettingshausen "*Diospyros eocenica* Ett."
V. 22351 An endocarp and three seed-casts. *Reid & Chandler Coll.*, Minster, 1929.
V. 22352 Four seed-casts; probably belonging to this species. *Reid & Chandler Coll.*, Minster, 1929.
V. 22353 An endocarp, now broken, so as to show the seed-cast within. *Toulmin Smith Coll.*, Sheppey.

All the above, unless otherwise stated, are from the Bowerbank Coll., Sheppey.

Laurocarpum ovoideum n. sp.

PLATE VII, figs. 35–38.

1879. *? Corylus primigenia* Ettingshausen, p. 394.

DIAGNOSIS.—Berry probably borne on a swollen peduncle, ovoid, ribbed longitudinally; mesocarp thick, especially at the base; endocarp 0·1 to 0·15 mm. thick, columnar in section; locule excentric, nearer the apex than the base. Seed ovoid or globular; testa with outer coat of a single layer of secreting cells variable in size and form and with sinuous walls, inner coat of small square or polygonal cells.

HOLOTYPE.—V. 22354.

DESCRIPTION.—*Berry:* One-loculed, one-seeded, with pendulous seed; ovoid, obscurely ribbed longitudinally (Pl. VII, fig. 38), probably borne on a much enlarged peduncle (as evidenced by a large basal scar of attachment); locule excentric, nearer to the apex of the fruit than the base; placenta sub-apical; pericarp formed of three coats: (1) a thin epicarp about 0·025 mm. thick, formed of polygonal cells 0·015 mm. in diameter which in radial sections of the fruit show a columnar arrangement; (2) a greatly developed mesocarp which at the base is formed of a thick fibrous core and a peripheral fibrous envelope, with a mass of elongate pulp (?) cells between them; at the upper end of the fruit of several layers of radially compacted cells, especially well-developed around the placenta; and in the middle of the fruit of two compacted coats into which the single apical coat has divided, one peripheral, one surrounding the locule, the space between being filled by pulp (?) cells (smaller towards the periphery) variously aligned and presenting a tortuous appearance, and with globular secreting cells interspersed; (3) an endocarp 0·1 to 0·15 mm. thick formed of large cells (perhaps a single layer) which in surface view have irregular shapes and tortuous confused outlines, and in sectional view are columnar. Length of berry, 9 to 16·5 mm.; diameter, 10·5 to 13·5 mm.

Seed: Ovoid or globular; anatropous, with the hilum at the end turned to the apex of the fruit, raphe lateral (Pl. VII, fig. 37) but branching and anastomosing freely, so as to form a network over the chalaza, the inner chalaza smooth and occupying about one-third of the length of the seed at the end opposite to the hilum; micropyle adjacent to the hilum; testa formed of two coats, the outer, one cell thick, formed of large secreting cells of variable size and shape with thick sinuous walls, and an inner coat of small square or polygonal cells. Diameter of seed, 10 to 10·5 mm.

Remarks and Affinities.—Four specimens, all much broken. The species would be difficult to recognize from external characters alone, the only distinctive features being the oval form, ribbed surface, and basal scar of attachment, but in longitudinal section the fruit is very distinctive. The evidence for a swollen receptacle is seen in the large basal scar of attachment. The structure of the carpellary and seed coats, as well as the character and position of the large chalaza, point indubitably to the fruit belonging to the Lauraceae. Nevertheless we have been unable, by a study of the material at our disposal, to discover what is its generic relationship; especially as we have seen no species with a mesocarp of similar type. We have therefore referred it to the form-genus *Laurocarpum* under the name *L. ovoideum*. But failure to trace the nearer relationship is quite possibly due to the very limited amount of material that it has been possible for us to study in any detail. One specimen (V. 22357) was numbered by Ettingshausen, the number corresponding with an entry in the old register "3 *Corylus eocenica*." This was the only species of *Corylus* registered from the London Clay, and only one species, *Corylus primigenia*, appears in Ettingshausen's list. It seems probable, therefore, that the two names are synonymous; for Ettingshausen frequently changed his mind as to the most appropriate name between registering a species and listing it for publication.

V. 22354 Holotype, figured Pl. VII, figs. 35–37. A fruit, pericarp now broken in pieces so that the seed is exposed. The raphe and chalaza are clearly visible.
V. 22355 Figured Pl. VII, fig. 38. A fruit, broken as in the preceding case.
V. 22356 A fruit, fractured longitudinally, and imperfect.
V. 22357 A small fruit. Probably Ettingshausen's "*Corylus primigenia.*"
All are from the Bowerbank Coll., Sheppey.

Laurocarpum proteum n. sp.

Plate VII, figs. 39–43.

Diagnosis.—Berry ovoid, with a large scar of attachment; mesocarp and endocarp fused together, formed of an outer coat of parenchyma and longitudinal rows of cells, a middle coat of large radially aligned prismatic cells, an inner columnar coat 0·1 mm. thick. Seed ovoid, with a large sub-triangular or ob-cordate depression associated with a beaked prominence which carries the raphe; testa (sometimes 5 mm. thick) formed of loose parenchyma; chalaza circular, covering the lower fifth or sixth of the seed.

Holotype.—V. 22358.

Description.—*Berry:* One-loculed, one-seeded, seed pendulous from the apex; ovoid, with a large circular scar of attachment (Pl. VII, fig. 40), 11 mm. in diameter, which probably implies a swollen peduncle; epicarp smooth and shining, 0·1 mm. thick, formed of close-set polygonal cells 0·016 mm. in diameter, which give a minutely tessellated surface to the fruit; mesocarp and endocarp more or less fused so that no definite boundary separates them, the coats forming them being: (1) an outer coat of parenchyma and cells arranged in longitudinal rows which is about 1 mm. thick at the base, but thins quickly higher up, becoming so thin towards the apex as to be distinguished with difficulty; (2) an inner coat (2 to 2·5 mm. thick) which is fused with the last so that the boundary between the two is very irregular; this coat is formed of two parts which are also fused, the exterior part formed of broad but short prismatic cells radially aligned (Pl. VII, fig. 39), and the interior part (about 0·1 mm. thick) of smaller and more compacted cells with columnar arrangement, which is most easily distinguished from the outer part by the darker colour and greater resistance to wear of its cells. (In one specimen, but only in one, this columnar coat was free from the prismatic coat at the hilar end of the seed.) Length of fruit (imperfect) estimated at 21·5 mm.; diameter, 18·5 mm. Length of second specimen, 22 mm.; diameter, 19 mm.

Seed: Ovoid or sub-globular, beaked at the hilar end, the beak being delimited laterally by two ridges which form the lateral margins of a large triangular or ob-cordate depression (Pl. VII, figs. 41, 42); anatropous, the hilum being at the tip of the beak, the raphe lying medianly within the beak, and the smooth shining internal chalaza occupying from one-fifth to one-sixth of the length of the seed at the end opposite the hilum; testa of variable thickness, sometimes 5 mm. (Pl. VII, fig. 43), formed of three coats, an outer coat (seen only on the holotype) of secreting cells at least 0·1 mm. in diameter, which are now filled with glittering pyrites, a middle coat of loose parenchyma (heavily impregnated with pyrites in the fossils) with rough outer surface, and an inner smooth coat of small polygonal cells, 0·016 to 0·05 mm. in diameter, which are aligned transversely around the margin of the chalaza but longitudinally elsewhere. The specimens vary considerably in their dimensions owing to distortion. A well-preserved seed measures, length 15 mm.; diameter, 14 to 16 mm. A second specimen measures, length, 15 mm.; diameter, 15 mm.

Remarks and Affinities.—Nine specimens, six of which have part of the carpel preserved, and two fruits, which probably belong to this species. The fruit selected as the holotype shows a well-preserved epicarp, but is imperfect at the apex; it nevertheless furnishes the most complete information regarding the structures of fruit and seed. When the carpel is preserved these fruits show no characters which suggest any relationship to the isolated seeds. It is only when fractured that the very peculiar form of the seed, as well as its structure, makes it certain that the fruits and seeds belong to the same species. The structure, both macroscopic and microscopic, places it beyond a doubt in the family Lauraceae. But, with the very limited amount of material available for our study of the family, we were unable to find any genus showing a similar mesocarp and endocarp. It is possible that the very marked beak at the hilum, emphasized by the large depression beneath it, may be a secondary character due in some measure to shrinkage, for we have seen the shrunken seed in *Phoebe gratissima* Gaertn. assume the same shape. Whether the unshrunken seeds also show it we do not know, for we have never seen them either in this or in any other species of *Phoebe*. Nor can we state, from our very limited knowledge of living seeds, whether this appearance is frequent or rare in the family. The structure of the fruit and seed, apart from this one feature, gives no warrant for relating it to *Phoebe*. Being unable to trace its relationship we have placed it in the form-genus *Laurocarpum* under the name *L. proteum*.

V. 22358 Holotype, figured Pl. VII, figs. 39, 40. The broken remains of a fruit and seed, showing the epicarp and scar of attachment, and the secreting cells of the testa.

V. 22359 Figured Pl. VII, figs. 41–43. A seed, now broken, showing the large ob-cordate scar at the hilar end. The section of the seed shows the chalaza and the thickness of the testa.

V. 22360 Remains of a fruit and a broken seed, showing the smooth chalazal scar and an unusually thin testa.

V. 22361–64 Four examples of seeds with broken remains of the fruit.

V. 22365 Half of a seed.

V. 22366 A crushed seed (now broken), showing testa, raphe and chalaza.

All the above are from the Bowerbank Coll., Sheppey.

V. 22367 Two fruits (now fractured) which probably belong to this species. *Reid & Chandler Coll.*, Minster, 1929.

Laurocarpum minimum n. sp.

Plate VII, figs. 44, 45.

Diagnosis.—Endocarp ovoid, conical at the apex, without a marked apical depression, 7 mm. long; wall, about 0·1 mm. thick, columnar in section, cells 0·03 mm. in diameter. Seed ovoid, chalaza small, occupying the surface at the lower end of the seed for about a sixth of its length.

Holotype.—V. 22368.

Description.—*Endocarp:* One-loculed, one-seeded, with seed pendulous from the apex of the locule; ovoid, conical at the apex, foramen of the funicle small, at the extreme apex, which has no marked depression such as is seen in many species; placenta apical; endocarp wall, about 0·1 mm. thick, showing a columnar structure in radial section, but in surface view the cell-walls are very tortuous and confused; the cells measure 0·03 mm. in diameter. Length and breadth of endocarp never really seen, as the endocarp wall remains in patches only.

Seed: Ovoid; anatropous, with hilum close to the placenta, raphe lateral, chalaza circular in outline, about 2·5 mm. in diameter, occupying the flattened or slightly convex end opposite the hilum, and covering about one-sixth of the length of the seed, micropyle adjacent to the hilum; testa formed of an outer layer (or possibly of two layers?) of large polygonal cells, frequently 0·15 mm. in diameter, containing a black secretion, within which is a delicate thin coat formed apparently of two layers of cells, one of which gives rise to fairly conspicuous narrow longitudinal striations above the chalaza, and the other to horizontal striations near the micropyle. We could not ascertain which of these coats was the outer. The internal cast of a typical undistorted seed measures, length, 7 mm.; diameter, 5 mm.

Remarks.—Four (or five?) specimens appear to be referable to this species. All are locule-casts or internal casts of seeds, but fragments of the endocarp still cling to one or two of these, and show its characters clearly. In some specimens it remains at the extreme apex showing the conical form and absence of a funicular depression. Judging from the comparatively small degree of distortion it is probable that the walls, although thin, were hard and resistant.

Affinities.—The structure of endocarp and seed are typical of the Lauraceae. The species must belong to one of the many genera with small, ovoid fruits, but also to one with a small chalaza. Genera such as *Cinnamomum*, *Sassafras*, *Lindera*, *Litsea* or *Neolitsea* have small fruits, but in no living genus have we seen a species with such a small chalaza as is found in the fossil. At the same time, it cannot be too strongly emphasized that in order to compare the chalazas, it is necessary to dissect the fruits and, for this, our opportunities have been extremely limited. Therefore we are left with inadequate information as to the probable relationship.

A lauraceous fruit found by ourselves at Minster may belong to this species. The endocarp is conical above as in *L. minimum* and the measurements of coats and cells agree with the corresponding measurements in that species. The length of the specimen is 6 mm. The seed is not sufficiently exposed for the size of the chalaza to be seen, and as it is not well-developed it is not easy to dissect it from the endocarp, but a striate coat is visible. The importance of the specimen lies in the preservation of the epicarp, so that if it should really belong to *L. minimum*, we can add to the description of that species the further fact that the surface of the epicarp is closely tessellated, the polygonal cells which form it measuring 0·02 mm. in diameter.

V. 22368 Holotype, figured Pl. VII, fig. 44. An endocarp. The coats of the testa are well seen.
V. 22369 Figured Pl. VII, fig. 45. A seed-cast, with part of the testa preserved. The specimen shows the chalaza very clearly.
V. 22370 Two specimens with part of the testa preserved.
All the above are from the Bowerbank Coll., Sheppey.
V. 22371 A fruit with epicarp preserved, and shrivelled seed not well seen. It may belong to this species. *Reid & Chandler Coll.*, Minster.

Laurocarpum minutissimum n. sp.

Plate VIII, figs. 1–3.

Diagnosis.—Berry sub-globular, 4 mm. long; epicarp thin, cells 0·02 mm. in diameter; endocarp ovoid, wall columnar, 0·1 mm. thick, cells 0·025 mm. in diameter. Seed ovoid, chalaza 2·5 mm. in diameter, occupying one-eighth of the length of the seed ; testa formed of polygonal cells 0·1 to 0·15 mm. in diameter, less regular in size and shape than the testa cells of *L. minimum*.

HOLOTYPE.—V. 22372.

DESCRIPTION.—*Fruit:* A berry, sub-globular, one-loculed, one-seeded ; epicarp thin, formed of small cells, 0·02 mm. in diameter, giving a minutely tessellated surface, the cells having a columnar appearance as seen in section. Mesocarp, much decayed, formed of loose-textured parenchyma ; endocarp ovoid, 0·1 mm. thick, formed of cells 0·025 mm. in diameter arranged in a columnar manner. Length of fruit (base broken), 4 mm. ; diameter, 5 mm.

Seed: Similar in shape to the endocarp, anatropous, with hilum towards the apex of the fruit ; chalaza circular, 2·5 mm. in diameter, occupying about one-eighth of the length of the seed at the opposite extremity to the hilum and adjacent micropyle. Testa formed of polygonal cells, fairly regular in shape, 0·1 mm. in diameter, occasionally 0·15 mm. Length of seed, 4 mm. ; diameter, 3·5 mm.

REMARKS.—Four specimens. Two are seed-casts with remains of the endocarp ; one, which may belong to this species, has remains of the endocarp preserved ; and one, taken as the holotype, is a perfect berry which was fractured to facilitate study.

AFFINITIES.—That the specimens belong to the Lauraceae there can be no doubt. We have found living species with berries as small in *Litsea*, *Benzoin*, *Actinodaphne*, and *Cassytha*. In all these genera, except *Cassytha*, the chalaza is much larger than in the fossil species. On this account we cannot, therefore, refer the fossil to any of the three. Nor can it be referred to *Cassytha*, for this genus has an accrescent calyx which envelops the whole fruit, as was evidently not the case in the fossil. It differs from *Laurocarpum minimum* (p. 231) in its smaller size, in the finer endocarp cells, and in the lesser size and more regular shape of the majority of the testa cells. We have therefore given it a distinct specific name to indicate the very small size.

V. 22372 Holotype, figured Pl. VIII, fig. 1–3. A berry, now fractured to show the structure of the carpel wall and seed. *Reid & Chandler Coll.*, Minster, 1929.

V. 22373 Two endocarps. *Bowerbank Coll.*, Sheppey.

V. 22374 An endocarp, which may belong to this species but has rather a large chalaza. *Reid & Chandler Coll.*, Minster, 1929.

Laurocarpum pyrocarpum n. sp.

PLATE VIII, fig. 4.

DIAGNOSIS.—Fruit pyriform, about 16 mm. long ; pericarp (as preserved) formed of two coats, the outer of stellate groups of cells with fibres embedded near the periphery, the inner columnar, not discontinuous.

HOLOTYPE.—V. 22375.

DESCRIPTION.—*Fruit:* Pyriform ; one-loculed, one-seeded ; carpellary coats (as preserved) two, the outer (mesocarp ?, much worn and decayed) formed of narrow elongate cells arranged in stellate clusters and with fibres embedded near the periphery, which probably branch from much decayed fibres at the base of the fruit ; the inner (endocarp) columnar in section and not discontinuous as in some genera in which stellate groups of cells occur, 0·1 mm. thick, formed of cells 0·025 to 0·05 mm. in diameter which give a tessellated surface to the locule-cast. Length (as preserved), 16 mm. ; diameter, 9 mm.

Seed: Much shrunken and decayed so that the interspace between it and the endocarp has been filled with pyrites, the seed-impression on the inner surface of this pyrites showing a few small polygonal cells.

Remarks and Affinities.—Two specimens. The surface of these, as preserved, is much decayed and very rugged, a frequent state of preservation in those Lauraceae which have the fruit wall composed in part of stellate groups of cells. The affinity to Lauraceae is established beyond question by the structure of the pericarp. The specimens differ from those described as *Beilschmiedia pyriformis* (p. 207) in their much smaller size, in the continuity and good definition of the columnar coat, and in the relatively small and narrow elongate cells which form the stellate clusters.

V. 22375 Holotype, figured Pl. VIII, fig. 4. An abraded fruit. *Bowerbank Coll.*, Sheppey.
V. 22376 A broken and abraded fruit. *Bowerbank Coll.*, Sheppey.

Laurocarpum crassum n. sp.

Plate VIII, figs. 5, 6.

Diagnosis.—Endocarp obovoid, with a beak-like prominence overhanging a large ob-reniform depression at the placenta, wall columnar, 0·1 mm. thick. Seed of similar shape to the endocarp ; chalaza probably occupying more than half the surface of the seed ; testa thick.

Holotype.—V. 22377.

Description.—*Endocarp:* One-loculed, one-seeded ; obovoid, with a conspicuous beak-like prominence through which the funicle passes into the locule to form the placenta, which is associated with a large ob-reniform depression on the endocarp ; wall columnar in section, 0·1 mm. thick around the placental depression, where alone it is preserved. Length of locule-cast with remains of endocarp at the placenta, 18 mm. ; diameter of locule-cast, 14 to 17·5 mm.

Seed: Similar in shape to the locule-cast ; chalaza occupying more than half the surface at the end away from the hilum ; testa, measuring in parts 2 to 3 mm. in thickness, formed of several layers of compressed polygonal cells which are more compacted towards the seed-cavity, the surface of which is smooth and formed of small polygonal cells 0·016 mm. in diameter. The seed cannot be accurately measured, the chalazal end alone being exposed.

Remarks.—Two locule-casts with remains of the carpel adhering around the placenta. Both are broken so that the chalazal ends of the seeds are exposed in a greater or lesser degree. In the specimen taken as the holotype the chalaza is not so well seen as in the other specimen, which shows it covering half of the surface and continued beneath the adhering locule-cast out of sight, so that it must have occupied more than half of the surface.

Affinities.—That the specimens belong to Lauraceae the form and structure, so far as this is preserved, show quite definitely. We have seen a somewhat similar beak and placental depression in a living species, but further discussion of these characters will be found under *L. proteum* (p. 231). The beak and depression are smaller than in *Endiandra crassa* and very much smaller than in *Laurocarpum proteum*, also the beak is less sharply angled than in the latter species.

V. 22377 Holotype, figured Pl. VIII, figs. 5, 6. A locule-cast. *Bowerbank Coll.*, Sheppey.
V. 22378 A locule-cast. The cast and testa inside it are chipped away at the basal end of the specimen to show the seed-cast within. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 9

Plate VIII, fig. 7.

Description.—*Fruit:* A broadly ovoid drupe, one-loculed, one-seeded. Epicarp wanting. Mesocarp, from 2 to 3 mm. thick, formed of two coats, rather ill-defined on their contiguous surfaces; the outer coat is apparently more decayed than the inner, since it shows many interstices filled with structureless pyrites; the cells appear to have been parenchymatous. Where the outer coat is abraded, thin flat bands of fibres lying on an uneven ill-defined surface, are exposed between it and the inner coat, which is formed of coarse, granular, secreting parenchyma such as is typical of many Lauraceae with succulent berries. The endocarp is 0·35 mm. in thickness, and quite distinct from the mesocarp, from which it is now separated by a layer of intercalated pyrites; the cells have a columnar arrangement, as seen in section, but in surface view they appear to be deeply-rayed. Length of fruit, 21 mm.; maximum breadth, 25 mm.; minimum breadth, 18 mm.

Seed: Similar in shape to the fruit; chalaza turned towards the base of the fruit, raphe branching over it; testa at least 0·2 mm. thick (difficult to measure on account of disintegration), formed of several, much compressed layers of large cells. Lining layer smooth and shining, finely striate longitudinally.

Remarks.—One specimen. The pericarp is worn away over the top of the fruit except around the placenta, where it still adheres, the outer layer of the testa being exposed elsewhere. In an attempt to remove the pericarp from the base of the fruit so as to expose the chalaza, the specimen shattered, showing that it was merely a hollow cast, but it is possible to detect the chalaza by the impression of branching fibres on the smooth internal cast of the testa.

Affinities.—There can be no doubt that the fossil belongs to the Lauraceae. All the characters of the pericarp, and those of the seed so far as they have been seen, indicate that family. But the evidence is insufficient for a closer determination.

V. 22379 Figured Pl. VIII, fig. 7. A fruit, originally abraded so as to expose the endocarp and seed-cast. Now shattered and broken. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 10

Plate VIII, fig. 8.

Description.—*Fruit:* Sub-globular or ovoid (much distorted), one-loculed, one-seeded; epicarp abraded. Mesocarp thick (in places as much as 3·5 mm.), formed of coarse fusiform cells arranged more or less radially (Pl. VIII, fig. 8) but on the inner surface, and occasionally in the thickness of the wall, showing a stellate arrangement of the cells ; endocarp columnar as seen in radial sections of the fruit. Length of fruit imperfect ; diameter (as distorted by compression from base to apex), 22 mm.

Seed: Conforming to the shape of the locule ; testa formed of an outer coat of loose tissue, with cells of various sizes and shapes, followed by a coat, 0·15 mm. in thickness, of narrow oblong cells from 0·025 to 0·33 mm. broad and two or three times as long, which give rise to longitudinal or oblique striations ; cotyledons probably hemispherical. Length of seed, 23 mm. ; diameter, 14 to 20 mm.

Remarks and Affinities.—One specimen. The greater part of the mesocarp is preserved, but has been detached from the seed-cast in order to display the anatomy of the seed as far as possible. The decaying remains of the endocarp adhere to the shell of mesocarp. The chalaza has not been seen, but the seed is much crushed and distorted ; its appearance suggests that the margin of one cotyledon has been pushed partially over that of the other thus concealing the junction of the two (Pl. VIII, fig. 8, right-hand bottom corner). The chalaza may have formed a band along this line of junction, as the striae diverge from its edges. If so it may belong to *Beilschmiedia*, but the evidence available is inconclusive. It is, however, certain that it belongs to the Lauraceae.

V. 22380 Figured Pl. VIII, fig. 8. A fruit, much crushed, with mesocarp and endocarp detached to show the seed. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 11

Plate VIII, figs. 9, 10.

Description.—Neither the complete berry nor endocarp of this species has been seen. A fragment of the endocarp adhering around the funicular opening and placenta is columnar in radial section and measures 0·6 mm. in thickness.

Seed: Ovoid, pointed at the hilar end, the hilar depression being large ; anatropous, with hilum adjacent to the placenta, raphe flat and lateral (Pl. VIII, fig. 10), chalaza, circular in outline, covering the rounded end of the seed opposite to the hilum for a third of its length (Pl. VIII, fig. 10) ; testa formed of secreting cells large in the outer layers, smaller in the inner. Length of seed, 16 mm. ; diameter, 12 mm.

Remarks and Affinities.—One undistorted seed with remains of the endocarp adhering around the hilar end, that is, the placental end of the endocarp ; the hilar depression although only partly exposed (Pl. VIII, fig. 9, top, left side) can be seen to be large and of a form not unusual in Lauraceae. The structure of the endocarp and testa, also the character and position of the chalaza and the form of the seed with the peculiar hilar depression, leave no doubt at all that this seed belongs to the Lauraceae. In the combination of form, size, and character of the hilar depression and chalaza it differs from the other species of Lauraceae found at Sheppey. From *Laurocarpum pyrocarpum* (p. 233), to which its shape might suggest an alliance, it differs in its much thicker endocarp.

V. 22381 Figured Pl. VIII, figs. 9, 10. A seed with remains of the endocarp. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 12

PLATE VIII, figs. 11, 12.

DESCRIPTION.—*Endocarp:* Ovoid (compressed as the result of fossilization), one-loculed, one-seeded, with a pendulous seed, and a transverse aperture at the apex for the passage of the funicle to the placenta (Pl. VIII, fig. 12); wall about 0·4 mm. thick where preserved around the placental aperture, formed of cells which in surface view are digitate and interlocking, and in radial sections of the fruit are columnar in arrangement. Length as preserved, 20 mm.; breadth, from 8 to 14 mm. owing to distortion.

Seed: Ovoid; testa thick (0·6 mm.), the external layer formed of rather small cells (0·03 mm. in diameter), within which are many layers of large globular secreting cells of varying size, many being 0·1 mm. in diameter.

REMARKS AND AFFINITIES.—The specimen was evidently soft, as it has been much distorted by compression during fossilization. It was labelled by Ettingshausen "*Theobroma* sp. 2." The structure and form of this fossil with its columnar outer coat pierced at the apex by a large transverse foramen, the evidence of a seed lying within it with a testa formed in part by layers of large secreting cells, place its relationship with the Lauraceae and not, as Ettingshausen imagined, with *Theobroma*. It may, but probably does not, belong to one of the species already described, but is too crushed and distorted to make possible a satisfactory comparison. It is worthy of description mainly because of the desirability of correcting a misleading determination.

V. 22382 Figured Pl. VIII, figs. 11, 12. A fruit, crushed, labelled by Ettingshausen "*Theobroma* sp. 2." *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 13

PLATE VIII, figs. 13, 14.

DESCRIPTION.—*Fruit:* A globular, one-loculed, one-seeded berry; epicarp wanting; mesocarp thick, varying from 2·5 mm. at the base to 4 mm. at the apex, formed of coarse parenchyma intermingled with elongate cells which are often arranged in stellate groups; endocarp, 0·4 mm. thick, formed of small cells with a columnar arrangement as seen in radial section (Pl. VIII, fig. 14). Length, 25 mm.; diameter, 20 to 24 mm.

Seed: Globular. Testa 0·5 mm. thick, formed of several layers of radially compressed, rather large cells.

REMARKS AND AFFINITIES.—Two fruits. One is fractured longitudinally and shows the coats of fruit and seed in section. The other is in four fragments, three of them showing the coat in section, the fourth being a fragment of the fused endocarp and testa which has become detached from the mesocarp. Both specimens show this fusion of endocarp and testa, which may either be original or the result of the infiltration of pyrites acting as a cement. In consequence of it we have been unable to trace either hilum, raphe, or chalaza, since the outside of the testa is obscured, and the inside is coated with granular pyrites, the seed-cavity being hollow. The detached fragment of fused endocarp and testa only shows the cells of the testa in a few places where the endocarp is worn away. The structure of mesocarp and endocarp place the specimen beyond a doubt in the Lauraceae.

V. 22383 Figured Pl. VIII, figs. 13, 14. A fruit, now fractured longitudinally to show the structure of the carpel wall.
V. 22384 A fruit, now in four fragments.
Both are from the Bowerbank Coll., Sheppey.

Laurocarpum sp. 14

PLATE VIII, figs. 15, 16.

DESCRIPTION.—*Fruit:* A one-loculed, one-seeded, ovoid berry. Pericarp largely abraded, endocarp wall columnar in section, about 0·2 mm. thick; aperture for the passage of the nutrient fibres to the placenta transverse, slit-like (Pl. VIII, fig. 16). Length of fruit as preserved, 12 mm.; diameter, 9·5 mm.

Seed: Ovoid; testa formed of small secreting cells, with an inner layer, the cells of which cannot be distinguished; the branching raphe in this layer covers more than three-quarters of the length of the seed, but the margin of the chalazal area is not distinguishable, as it is still covered by the remains of the locule-cast. There are slight indications of two plano-convex cotyledons.

REMARKS AND AFFINITIES.—One locule-cast, from the surface of which the carpel has largely been worn away but is preserved in a few furrows where it has been covered by pyrites. From much of the remaining surface the locule-cast, as well as the testa, has been removed so that the smooth internal cast of the chalazal end of the seed can be seen (Pl. VIII, fig. 15). There can be no doubt that the fruit belongs to Lauraceae. The species is noteworthy in that it is one of the few occurring in the London Clay in which the chalaza is as large as it is in the majority of living genera.

V. 22385 Figured Pl. VIII, figs. 15, 16. A locule-cast with a few remains of the much abraded endocarp in the furrows; locule-cast and testa in part chipped away to show the internal cast of the seed. The specimen is now much broken. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 15

PLATE VIII, figs. 17, 18.

DESCRIPTION.—*Fruit:* Large, globular, one-loculed, one-seeded, the seed being pendulous from the apex. Epicarp abraded. Mesocarp formed of large cells grouped into large stellate clusters, the cells nearer the centre of the cluster being long, those more remote becoming smaller, the small cells of one cluster merging with those of neighbouring ones. The coat is divided into two concentric shells by a layer in which are embedded tortuous fibres. Endocarp with a transverse funicular aperture at the apex, wall 0·3 mm. thick, formed of cells with columnar arrangement as seen in radial section of the specimen, and 0·05 mm. in diameter with deeply digitate outlines in surface view. Diameter of fruit, 16 mm.

Seed: Globular, anatropous, with hilum directed to the apex of the fruit, raphe lateral and branching over the chalaza at the opposite extremity of the seed to the hilum. Testa formed of several thicknesses of small cells of irregular polygonal shape. Length of seed, 11 mm.; diameter, 11 to 12 mm.

REMARKS AND AFFINITIES.—One berry, fractured before it came into our hands, so that part of the pericarp was lost, thereby exposing the locule-cast but not the seed. An attempt to remove part of the cast resulted in the remaining part of the pericarp coming away and a fragment breaking from the locule-cast. In this way the seed was exposed in such a manner as to show the hilum, raphe, and chalaza, and the structure of the testa. On the shell of pyrites which lies between the two coats of the mesocarp are the remains of the layer of tortuous fibres.

The relationship to the family Lauraceae is quite unmistakable, but the evidence is not such as to permit of more definite determination.

V. 22386 Figured Pl. VIII, figs. 17, 18. A fruit with part of the mesocarp preserved. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 16

PLATE VIII, fig. 19.

1879. *Diospyros eocenica* Ettingshausen (pars), p. 394.

About fifty specimens were in jars labelled by Ettingshausen "*Diospyros eocenica* sp. nov." Thirty of these are much abraded, crushed, internal casts of the seeds of a species of Lauraceae, as shown by the impressions of coarse secreting testa cells on some of the specimens (Pl. VIII, fig. 19), small adherent fragments of endocarp on others, traces of a large chalaza on others, and so on. All are now greatly distorted by pressure, but originally they appear to have been globular, so that the berry was probably thin-walled, soft, and compressible. The endocarp, as measured from fragments, is 0·1 mm. thick, formed of polygonal cells, 0·025 mm. in diameter as seen in surface view, and with a columnar arrangement as seen in radial section of the fruit. The testa is formed of two coats; the outer, apparently one cell thick, is formed of large angular cells, some of the angles being re-entrant, so that the cells interlock and produce a complicated surface pattern; the inner is formed of oblong or polygonal cells, 0·016 to 0·05 mm. in diameter. The cell-cavities of this coat are occupied in the fossil state by shining pyrites-casts. The berries measure 6·5 to 8 mm. in diameter in their present compressed condition.

In addition, seven specimens were found by ourselves at Minster and a specimen probably referable to this species was recently found at Herne Bay by Mr. D. J. Jenkins.

V. 22387 Figured Pl. VIII, fig. 19. A crushed berry, fractured to show the structure of the endocarp wall in section. *Bowerbank Coll.*, Sheppey.
V. 22388 Twenty-six similar specimens, which, with V. 22387, were labelled by Ettingshausen "*Diospyros eocenica* Ett." *Bowerbank Coll.*, Sheppey.
V. 22389 Seven fruits, crushed. *Reid & Chandler Coll.*, Minster, 1929.
V. 22390 Three crushed lauraceous berries, probably referable to this species, labelled by Ettingshausen "*Diospyros eocenica* sp. nov." *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 17

PLATE VIII, fig. 20.

DESCRIPTION.—*Fruit:* One-loculed, one-seeded, sub-globular but (as preserved) depressed dorsi-ventrally, the mesocarp being also worn away at the apex so that the conical placental end of the endocarp is exposed; mesocarp, 2·5 to 3 mm. thick, formed of parenchyma with a general radial arrangement and numerous stellate clusters of cells scattered throughout its thickness; endocarp well-defined, and not discontinuous, 0·2 mm. thick, with a columnar arrangement of cells as seen in section. Seed similar in shape to the endocarp; testa rather thicker than the endocarp, formed of radially compressed cells. Chalaza not seen. Length (abraded at apex), 16 mm.; diameter, 25 mm.

REMARKS AND AFFINITIES.—One specimen. The relationship to Lauraceae is unmistakably indicated by the character of the mesocarp and endocarp; but little is known of the seed. We have therefore assigned the specimen to the form-genus *Laurocarpum*, and have given no specific name.

V. 22391 Figured Pl. VIII, fig. 20. A fruit now fractured. The mesocarp is broken into fragments. *Bowerbank Coll.*, Sheppey.

Laurocarpum sp. 18

PLATE VIII, fig. 21.

DESCRIPTION.—*Fruit:* Preserved as the internal cast of the seed with remains of the endocarp and testa around the placenta and hilum; elongate-ovoid; endocarp columnar as seen in radial sections of the fruit.

Seed: Elongate-ovoid; chalaza large, occupying the greater part of the surface of the seed (exact limits not known); testa with one coat formed of polygonal secreting cells from 0·05 to 0·075 mm., or more, in diameter; embryo exalbuminous, cotyledons large, plano-convex. Length of specimen, 24 mm.; longer diameter, 14 mm.; shorter diameter, 12·5 mm.

REMARKS.—One specimen from Herne Bay. As stated, it is for the most part the internal cast of a seed, but at the placental and hilar end are remains of the endocarp and testa. The smooth surface appears to be that of the internal chalaza, which must therefore have been very large, covering a great portion of the surface, and consequently of similar proportions to the chalaza in many living species, although what were its exact limits we do not know. The division between the cotyledons is clearly visible at the hilar end, and less clearly visible at the opposite end of the seed. The remains of the endocarp and testa around the placenta are, superficially, much confused and obscured by adhering pyrites, but a freshly fractured surface showed their structure clearly.

AFFINITIES.—The form of the seed and cotyledons, the character of the testa and endocarp, and their mode of preservation at the hilar end of the specimen, make it certain that the seed belongs to the Lauraceae. It is tempting to think that the size, combined with the elongate shape and large chalaza, constitute a sufficient basis on which to diagnose a species, but a glance at our drawings of living Lauraceae shows that endocarps of similar shape and size occur in several genera. We cannot therefore use the shape, peculiar as it is among Sheppey Lauraceae, as a generic character by which to determine its affinity. Nor can we use the large chalaza, although that also is rather exceptional among Sheppey Lauraceae, for it is very common among living species. All we can do, therefore, is to distinguish it as a separate species, which, so far as the present evidence goes, is well-defined as regards the rest of the London Clay Lauraceae, but ill-defined as regards the living family. Nevertheless, if at any future time specimens of similar size and form, with a similar large chalaza, and with the pericarp preserved, should be found in the London Clay it would be highly probable that they would belong to this species, and that in the pericarp the evidence might be found for relating it to a living genus. Meanwhile we have referred the fossil to the form-genus *Laurocarpum* without giving it a specific name.

V. 22392 Figured Pl. VIII, fig. 21. A seed (internal cast), with remains of the testa and endocarp around the hilar end. *D. J. Jenkins Coll.*, Herne Bay, 1929.

Laurocarpum sp. 19

Plate VIII, fig. 22.

Description.—*Fruit:* With columnar endocarp, 0·05 mm. thick (preserved near placenta), having a curved, mouth-shaped funicular aperture.

Seed: Globular, with large exalbuminous embryo and plano-convex cotyledons. Chalaza large, exact limits not seen, but it covers at least seven-eighths of the length of the seed. Testa largely abraded, but a fragment still adheres around the hilum where it is 0·05 mm. thick and formed of several layers of radially compressed cells, possibly with a few large secreting cells. Length and breadth, 13 mm., perhaps more (in doubtful specimens).

Remarks.—An internal cast of a seed with fragments of testa and endocarp adhering at the hilum. The specimen shows clearly the shining surface of the chalaza, the obscure limits of which may be marked by the adherent remains of the testa. There are indications of a curved mouth-shaped aperture for the entrance of the funicle to the seed. Four other specimens of varying size may belong to this species, but the evidence available is very indefinite. All clearly belong to the Lauraceae.

V. 22393 Figured Pl. VIII, fig. 22, an internal cast of a seed with large chalaza.
V. 22394 Four seed-casts, which may belong to this species.
All are from the Bowerbank Coll., Sheppey.

Laurocarpum sp. 20

Description.—*Fruit:* One-loculed, one-seeded; with columnar endocarp 0·1 mm. thick (fragments preserved over parts of the surface).

Seed: Ovoid; anatropous, with a lateral raphe in the thickness of the testa, which indicates that the hilum and chalaza, although not seen, were at opposite ends of the seed; testa with an outer coat of fairly regular polygonal cells 0·1 mm. in diameter, and an inner coat of small oblong cells aligned longitudinally. Length of seed, 7·5 mm.; diameter, 6·5 mm.

REMARKS.—One seed with fragmentary remains of the endocarp. The importance of this specimen lies in the fact that it was obtained from the Basement Bed of the London Clay at Harefield, Middlesex, of which the flora is but little known. Its characters can only be seen after careful scrutiny under the microscope. The specimen has, therefore, not been figured, since it would merely appear as an ovoid body devoid of structure.

V. 22395 A seed from the Basement Bed of the London Clay at Harefield, Middlesex. *H. A. Toombs Coll.*

Laurocarpum spp. indet.

Below are catalogued various specimens which show a sufficiency of lauraceous characters to relate them indubitably to the family, but which are so badly preserved as to have lost any specific characters. We have not always stated what are the characters which pointed to alliance with the Lauraceae, but it must be understood that they are some of those enumerated in the introduction to the family. Some few of the specimens catalogued below are of importance solely because of the relationships previously ascribed to them by Ettingshausen, which are now known to be erroneous and misleading.

V. 22396 Three specimens, possibly all different, which were in a jar, with other fruits here catalogued as *Laurocarpum* sp. 16 (V. 22390), labelled by Ettingshausen "*Diospyros eocenica* sp nov."

V. 22397 Five fruits or seeds, labelled by Ettingshausen "*Cotoneaster Sheppyensis* sp. nov." Probably all do not belong to a single species; but their characters are ill-defined or poorly preserved, so that the specimens are not worth description. One at least shows the characteristic large lauraceous chalaza and traces of the mouth-like funicular aperture; another shows the raphe branching over the chalazal area; a third shows the testa with characteristic secreting cells, and the columnar endocarp around the placental foramen and depression. A fourth specimen is the worn cast of a seed on which remains of testa cells are just recognizable. A fifth shows mesocarp, columnar endocarp, seed with branching raphe and testa formed of secreting cells. Its diameter is 13·75 mm.

V. 22398 Six fruits and several fragments belonging to Lauraceae, although they are otherwise indeterminable. Labelled by Ettingshausen "*Diospyros eocenica* Ett."

V. 22399 A small lauraceous seed, now broken, showing the large chalaza, and the coarse secreting cells of the testa. Labelled by Ettingshausen "*Sabal punctata.*"

V. 22400 Four small fruits, labelled by Ettingshausen "*Elaeis eocenica* Ett." They show definite lauraceous characters—large chalazas and secreting testa cells. Their characters are not sufficiently distinctive to permit of closer determination.

V. 22401 Fragments of eight much decayed small specimens showing various lauraceous characters, labelled by Ettingshausen "*Sabal major* Ung. sp." The specimens are mainly abraded internal seed-casts; their condition is such that only prolonged study of well-preserved Lauraceae from Sheppey has made it possible to recognize their true nature from such shreds of evidence as patches of the secreting testa cells, traces of the mouth-like opening which admits the funicle to the placenta, and so on.

V. 22402 A small globular lauraceous fruit which has been crushed from base to apex. It is a seed-cast, the secreting testa cells being preserved on its surface. Remains of the endocarp adhere in parts, showing columnar structure. The diameter is 9 mm.; the thickness 2·5 mm. The specimen was labelled "*Strychnos* sp. n. Ett." No doubt Ettingshausen was led to make this ascription on account of the compressed form, but the structure is quite unlike that of a *Strychnos* seed, in which the micropyle is marginal and the testa is formed of a mat of fibres radiating from the centre of each face flat to the margin.

V. 22403 Three well-preserved seeds showing chalazas and testa cells. Referable to the Lauraceae.
V. 22404 Four ovoid seeds belonging to the Lauraceae.
V. 22405 Four small sub-globular seeds belonging to the Lauraceae.
V. 22406 Seventy-five fruits or seeds, and numerous fragments, all of which are clearly referable to the Lauraceae. Their characteristics are too ill-defined or their preservation too poor to permit of closer determination.
V. 22407 Two specimens which are undoubtedly indeterminable Lauraceae. Labelled by Ettingshausen "*Carpolithes* sp. n. 21."
V. 22408 Two fruits represented by remains of cupules. In one the seed is also preserved. Both are referable to the Lauraceae, but are otherwise indeterminable.
V. 22409 An internal cast of a seed fractured longitudinally along the plane between the two cotyledons.
The above are all from the Bowerbank Coll., Sheppey.
V. 22410 A compressed and distorted fruit, now broken, belonging to the Lauraceae. *Reid & Chandler Coll.*, Sheppey, 1928.
V. 22411 135 fruits or seeds belonging to the Lauraceae, otherwise indeterminable. *Reid & Chandler Coll.*, Minster, 1929.
V. 22412 An indeterminable fruit of Lauraceae. *D. J. Jenkins Coll.*, Herne Bay.

? *Laurocarpum* sp. 21

Plate VIII, figs. 23, 24.

Description.—*Fruit:* Ovoid, one-loculed, one-seeded. Surface regularly (?) dimpled (the effect of shrinkage? see Pl. VIII, fig. 24). Epicarp formed of close-set polygonal cells, smooth. Mesocarp, 1·5 mm. thick, formed of radially arranged parenchyma cells. Endocarp also formed of parenchyma. Over its surface there is a conspicuous network of fibres, arising as a few longitudinal strands at the base, where there is a small scar (probably the attachment); thereafter they branch and anastomose as they ascend, until over the apex they form a uniform, coarse network, except that four of the strands, over the four quarters of the fruit, run a conspicuous longitudinal course. Two of the four meet accurately at the apex dividing the fruit into equal halves. Length (as preserved), 16·5 mm.; diameter, 12 to 14 mm.

Seed: The seed conforms to the shape of the locule. The testa is thin and appears to be formed of a few layers of radially compressed cells. The innermost layer is formed of small polygonal cells.

Remarks.—One specimen, which was fractured transversely and then showed the outline of the seed lying within the locule. In one or two places the endocarp broke away exposing, very inadequately, portions of the testa. The mesocarp and epicarp are preserved only in one minute fragment; over the surface of this fragment a few closely and apparently uniformly spaced dimples are seen (Pl. VIII, fig. 24).

Affinities.—The dimpled surface at first suggested that the fruit belonged to the Icacinaceae (§ Phytocreneae), but the epicarp cells are not those of Icacinaceae; also we have not seen in that family a fibrous layer forming part of the endocarp, although a similar layer occurs in the closely allied family Olacaceae. The other characters of the fossil do not, however, agree with the Olacaceae. It seems more probable that it belongs to the Lauraceae, in which family the characters of epicarp, mesocarp, and testa occur. Against this attribution is the fact that no columnar layer can be seen lying within the fibrous layer. Nevertheless the columnar endocarp in the family Lauraceae is sometimes intermittent, or so thin as to be difficult to trace. In the absence of further evidence on this point, and of information regarding the structure of the seed, we have deemed it inadvisable to refer the fossil to the family Lauraceae with certainty.

V. 22413 Figured Pl. VIII, figs. 23, 24. A fruit, fractured transversely. *Bowerbank Coll.*, Sheppey.

? *Laurocarpum* sp. 22

Plate VIII, figs. 25–27.

Description.—*Fruit:* Broadly ovoid, with a large circular basal hole (Pl. VIII, fig. 26), perhaps associated with a stalk or cupule; one-loculed, one-seeded; pericarp thick, formed of large longitudinally elongate cells occasionally arranged in radiating groups and with many embedded longitudinal strands of fibres, followed by a smooth coat of elongate cells longitudinally aligned, on the surface of which are the remains of decayed organic matter which may represent a third coat. Length of fruit (? complete at the base), 20 mm.; greatest diameter, 30 mm.; least diameter, 26 mm.

Seed: Sub-ovoid, anatropous, with a thick branching raphe (seen over the smooth basal area); testa with an outer coat of small inflated cells variously aligned so as to produce an intricate pattern on the surface, and an inner striate coat, more than one cell thick, in which lies the branching raphe; upon the base of the seed, which is smooth, are the impressions of minute parenchymatous cells, and here also the testa is formed of several layers of cells. Length of seed, 17 mm.

Remarks.—A fruit which, although it had fallen to pieces, proved, when put together, to be almost complete. The broken internal cast of the seed was also preserved (Pl. VIII, fig. 27). The basal hole has a smooth finished margin, which suggests that it was structural, but the evidence cannot be regarded as conclusive.

Affinities.—Some of the characters described above recall those of certain genera of Lauraceae, though the structure of the pericarp is not altogether typical of the family. We have not found elongate longitudinally aligned cells in the mesocarp of any Lauraceae, although the groups of radiating cells recall that family, and there is no columnar endocarp preserved; nor is the testa typical. We have therefore referred the specimens tentatively only to the Lauraceae, and to the form-genus *Laurocarpum*.

V. 22414 Figured Pl. VIII, figs. 25–27. A fruit, now in fragments, seed-cast also incomplete. *Bowerbank Coll.*, Sheppey.

Genus ? sp. 1

Plate VIII, fig. 28.

A small ovoid specimen, with a conspicuous sub-reniform sunken scar at one end, may possibly be a lauraceous seed-cast. The specimen is much crushed, distorted, and puckered; it bears on its surface the impression of a tangled mass of short fibres or elongate cells, and beneath them small polygonal cells 0·015 to 0·025 mm. in diameter. The shape of the large scar suggests the depression sometimes associated with the placenta and funicle in the family Lauraceae. It is often seen on seed-casts to which a fragment of the endocarp has adhered around the hilum. The fibrous structure impressed on the surface of the cast is not, however, characteristic of the family. Hence the ascription must be regarded as doubtful. Length, 7 mm.; breadth, 7 mm.

V. 22415 Figured Pl. VIII, fig. 28. A seed-cast, much crushed. *Reid & Chandler Coll.*, Minster, 1929.

Genus ? sp. 2

PLATE VIII, fig. 29.

DESCRIPTION.—*Seed:* Barrel-shaped, with a longitudinal groove down one side which may indicate the margins of two appressed plano-convex cotyledons, anatropous, with branching raphe and small (?) circular basal chalaza. Testa of two coats: the outer formed of two or three layers of large polygonal secreting cells, 0·05 to 0·1 mm. in diameter, the inner, apparently only one cell thick, of minute oblong cells aligned longitudinally. Length, 17 mm.; diameter, 9 mm.

REMARKS AND AFFINITIES.—The characters described above suggest that the seed belongs to the Lauraceae. But in the absence of any portion of the endocarp we cannot feel sure of this relationship, especially as the chalaza and raphe are both somewhat obscured by pyrites. There are several living genera of Lauraceae which have seeds of this size and shape.

V. 22416 Figured Pl. VIII, fig. 29. A seed. *D. J. Jenkins Coll.*, Herne Bay, 1929.

Family SAXIFRAGACEAE

Genus SAXIFRAGISPERMUM nov.

DIAGNOSIS.—Fruit ovoid, five-carpelled, five-valved, syncarpous, one-loculed, 14 mm. long; placentation parietal, with several rows of seeds along each placenta embedded in a mass of fibres. Seeds 0·9 to 1 mm. long, ovoid acuminate, anatropous; testa of three coats, the outer coat closely spinescent, the spines being small and slender, middle coat thick and longitudinally striate, inner coat of small transversely elongate cells; tegmen formed of polygonal cells.

GENOTYPE.—*S. spinosissimum* n. sp.

Saxifragispermum spinosissimum n. sp.

PLATE VIII, figs. 30–35.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22417.

DESCRIPTION.—*Fruit:* Ovoid, syncarpous, five-valved, five-carpelled, apparently one-loculed; each valve bears a median longitudinal parietal placenta with about a dozen seeds arranged in several rows; the carpel wall is fibrous, the fibres appearing to arise from the placentas and to run transversely over the inner surfaces of the valves; the whole cavity of the locule appears to be filled with a mass of tortuous fibres which sweep (from the placentas ?) around and among the seeds

(Pl. VIII, figs. 33, 35). Length of fruit, 14 mm.; greatest breadth (distorted), 13 mm.; least breadth (distorted), 8 mm. The diameter was probably originally about 10 mm.

Seed: Ovoid, mucronate at the micropyle (Pl. VIII, fig. 33); anatropous, with the hilum at the mucronate end, which is the one adjacent to the placenta, raphe lateral, rather broad, and chalaza large and round at the end opposite to the hilum (Pl. VIII, fig. 32); micropyle adjacent to the hilum; testa spinescent, the outer coat formed superficially of equiaxial hexagonal cells 0·017 mm. in diameter, each bearing a small delicate spine (Pl. VIII, fig. 35) at its centre, the middle coat fairly thick, longitudinally striate from the micropyle to chalaza, the inner coat, which lines the testa, formed of oblong cells 0·02 mm. broad and 0·05 mm. long, the cells being transversely elongate, and over most of the surface aligned in longitudinal rows, but around the micropyle and chalaza in concentric rows; tegmen often crumpled, formed of polygonal cells about 0·016 mm. in diameter, which diverge from the micropyle and chalaza and form a smooth shining surface. Length of seed, 0·9 to 1 mm.; diameter, 0·7 mm.; length of spines, as much as 0·05 mm.

Remarks.—Two specimens; one is much worn so that the pericarp is destroyed and the rows of abraded seeds on both sides of the prominent placentas are exposed (Pl. VIII, figs. 30, 31). The other, which is imperfect, appears to have been burrowed into by some animal; it is the half of a fruit broken longitudinally, and is now in fragments. Yet part of the carpel is sufficiently well preserved to show the arrangement of the valves, one valve being partly broken and removed, so that the parietal placentas beneath are exposed. The more perfect specimen was fractured both longitudinally and transversely, the characters described being revealed. No trace of septa can be seen (Pl. VIII, figs. 32–35).

Affinities.—The most characteristic features of this fruit appear to be the five parietal placentas and the small ovoid spiny seeds. There are two families in which these characters are found—the Nymphaeaceae (*Barclaya*) and the Saxifragaceae (many genera). The seeds of *Barclaya* are larger, the coats of the testa are different, and the spines are much larger, more hooked, and fewer. In Saxifragaceae the seeds may be of similar size and shape; also, like the fossil, they may be closely spinescent, the spines being comparable in size and character. We have, moreover, seen corresponding coats in the testa. The evidence therefore suggests an alliance with the Saxifragaceae, although we have been unable to find any living genus combining all the characters seen in the fossil.

V. 22417 Holotype, figured Pl. VIII, figs. 30–35. A fruit, abraded so as to expose the five longitudinal parietal placentas, on each side of which are the numerous worn seeds arranged in rows. The specimen has been fractured into three pieces so as to expose its structure, and its unabraded seeds.

V. 22418 Half a worn fruit, now in many fragments. It showed some of the valves, one of the placentas where a valve had come away, and in the interior, fibres and a few seeds.

Both specimens are from the Bowerbank Coll., Sheppey.

Family HAMAMELIDACEAE

Genus PROTALTINGIA nov.

Diagnosis.—Fruiting head ovoid, agglomerate, with about twenty (or twenty-five ?) fruitlets sunk within as many sub-quadrilateral areoles formed by encircling strands of fibres ; length, 22 mm. Fruitlets two-loculed (abortive seeds four, a pair in each locule ?), locules antero-posterior, dehiscing and gaping loculicidally across the top of both locules ; pericarp formed of coarse cavernous tissue and of sub-parallel fibres which diverge from the top of a median fibrous axis. Seeds (?) with thin columnar testa.

Genotype.—*P. europaea* n. sp.

Protaltingia europaea n. sp.

Plate IX, figs. 1–5.

Diagnosis.—That of the genus.

Holotype.—V. 22419.

Description.—*Fruiting Head :* Ovoid, agglomerate, with a short fibrous axis ; the surface divided into about twenty (or perhaps as many as twenty-five) contiguous, quadrangular, pentagonal, or hexagonal areoles within which are cup-like or funnel-shaped hollows ; the areoles are delimited by broad ridges formed of thick strands of fibres which curve from ridge to ridge (Pl. IX, fig. 1) ; within each hollow is a fruitlet. Length of fruiting head, 22 mm. ; breadth, 16 mm. ; diameter of well-developed hollow, 6 mm. ; depth, 4·5 mm.

Fruitlets : Two-loculed, with antero-posterior locules (Pl. IX, fig. 3), capsular, splitting loculicidally in the first instance, the split extending across the top of both locules so that in the upper part of the dehisced fruit the lateral walls gape apart forming a trough-like hollow (which is filled with pyrites, Pl. IX, fig. 2), whilst in the lower part of the fruit the locules remain separated by the septum (Pl. IX, fig. 3) forming a pair of cup-shaped hollows (Pl. IX, fig. 5) ; the septum is traversed by a median longitudinal fibrous axis which extends to the level of the transverse split, but not beyond ; pericarp formed of sub-parallel fibres, which diverge transversely or obliquely from the top of the fibrous axis (Pl. IX, fig. 5), whilst associated with them, and enveloped by them, is a mass of coarse-textured cavernous tissue (Pl. IX, figs. 3–5).

Seeds : Doubtfully seen. Pairs of small elongate organic bodies embedded in the pyrites infilling (Pl. IX, fig. 2) occur in some of the locules. In section they appear to have columnar walls, a structure seen in the abortive seeds of *Liquidambar* and *Altingia* but not in the ripe ones. If these bodies do not represent seeds, we cannot explain their nature.

Remarks.—One fruiting head. The form at once suggested relationship to the Hamamelidaceae ; but as agglomerated fruits occur in other families, for instance in the Rubiaceae, we decided to fracture the specimen in order to study the individual fruits, the characters of which could not otherwise be satisfactorily determined. On fracture the specimen broke into several pieces, and although, owing to pyritization, the structure was still difficult to understand, we were able, by close study of the various sections available, to discover the essential characters.

In order to facilitate the understanding of the specimen, the mode of preservation may be described. Each of the trough-like hollows formed by the gaping of the lateral walls described above, and the two locules beneath, are now filled with pyrites. Above the level of the septum this pyrites forms an antero-posterior bar lying longitudinally athwart each of the hollows (Pl. IX, figs. 1, 2). On each side of this bar is, usually, one crescentic area filled by oblique or transverse fibres, and coarse cells or cavernous tissue, which are the decayed and abraded remains of the carpel walls (Pl. IX, fig. 4). This represents the typical form of preservation; but less commonly, at the septum, the bar of pyrites is constricted and the crescents instead of being simple are each divided at the middle to form two smaller crescents aligned end to end, so that in all, there are four crescents embracing the bar of pyrites. The difference in the two modes of preservation seems to correspond with the degree of abrasion which has taken place. When abrasion has not reached the level of the septum the crescents are large and simple (Pl. IX, fig. 2); when it has passed below the level of the septum, then the constriction occurs and the large crescents give place to two pairs of smaller ones. Pl. IX, fig. 4, shows one pair of small crescents, the other being broken away from the base of the figure.

Affinities.—In view of the characters described, there can be no hesitation in referring the fossils to the family Hamamelidaceae. Similar agglomerate fruiting heads occur in *Liquidambar* Linn. and *Altingia* Noronha. Those of *Altingia* more closely resemble the fossil than do those of *Liquidambar*, in the simpler character of the cup-like cavities which hold the fruits, in the presence of a short elongate axis in the fruiting head, and in the slightly ovoid form of that head as seen in certain species. The fruiting head in *Altingia* may be formed of from five to about twenty-four fruitlets. The outer part of the pericarp may be very cavernous as in the fossil. Nevertheless the fruiting head in *Altingia* is never so ovoid as in the fossil, nor are the carpel walls so markedly cavernous throughout their thickness. While, therefore, we have no hesitation in stating that a close relationship exists between the two, it seems advisable to place the fossil in a distinct genus, which we have named *Protaltingia*.

The genus *Altingia* embraces about four species of trees ranging from Yunnan to Java.

This specimen must not be identified with Ettingshausen's "*Liquidambar eocenicum*" (1879, p. 394). The fossil so labelled shows woody structure throughout and has none of the characteristics of the family Hamamelidaceae (cf. p. 540).

V. 22419 Holotype, figured Pl. IX, figs. 1–5. An agglomerate fruit, now fractured into many pieces.
V. 22419*a* The fragment of the holotype which is figured Pl. IX, figs. 2, 4.
V. 22419*b* Figured Pl. IX, fig. 5. An internal cast of a pair of locules from the holotype with remains of the septa and carpel walls.
Bowerbank Coll., Sheppey.

Genus ? (HAMAMELIDACEAE)

Plate IX, fig. 6.

Description.—*Seed:* Elongate, sub-ovoid, obliquely faceted at the broad hilar end, and narrowed at the other, anatropous, with a broad flat raphe arising from the margin of the hilar facet and lying along the shorter of the two sides of the seed; testa formed of four coats; the outermost of these is composed of narrow, oblong, slightly curved cells, from 0·05 to 0·15 mm. long, and about 0·02 mm. broad, with an irregular longitudinal alignment; the second is obscure and can be traced only by the general transverse alignment of its cells, which give rise to transverse striations; the third, one cell thick, formed of angular cells averaging 0·05 mm. in diameter, but irregular in shape and variously aligned, is clearly exposed in many places; the innermost coat is formed of small, regular, polygonal cells about 0·02 mm. in diameter. Length of seed, 7 mm.; dorsi-ventral diameter, 3·2 mm.; lateral diameter, 2·5 mm.

Remarks.—One specimen, which for the most part is the internal cast on a film of pyrites of the third coat of the seed, on which are the impressions of the cells forming that coat; but in many parts these impressions are confused by the superimposed impressions of the cells of the second coat; whilst in one small patch, near the broad hilar end, the hard outer coat is preserved; at the two ends the film of pyrites which forms the surface of the cast has been chipped away, and here the innermost coat is seen. The raphe is visible as a broad band of fibres arising from the margin of the hilar facet.

Affinities.—The shape and size of this seed with its faceted end at once suggest affinity with seeds of Hamamelidaceae belonging to the section Hamamelidoideae (Niedenzu in Engler, 1891, p. 121). In this section there is only one subovoid, obliquely faceted wingless seed of fairly symmetrical form, neither compressed nor indented by the pressure of other seeds. Its form is exactly that of the fossil. The relationship to Hamamelidaceae is further confirmed by the succession of seed coats. In the section Hamamelidoideae the seeds, so far as we have been able to study them (*Hamamelis* spp., *Corylopsis Willmottiae* Rehd. & Wils., *Fothergilla Gardeni* Murr.), have hard woody coats, the cells of which, at the hilar end, are similar to those found on the small patch of the outer coat preserved in the fossil. This hard outer coat is lined by a layer of large cells arranged more or less transversely so that they give rise to transverse striations, whilst adhering to this coat, on its inner face, is a single delicate layer of large angular cells with no definite alignment. The fossil is the internal cast of this third coat and, as we have seen, its surface shows most clearly the impression of the single layer of its delicate cells confused by the overlying impressions of the transverse cells. In the Hamamelidoideae these three coats form the hard testa. Within, but free from it, a soft coat of parenchyma gives a pitted surface to the seed-cavity. In the fossil the separation between the corresponding coats (the third and the innermost) is shown by the fact that the pyrites which bears the impressions of the cells of the third coat on its outer surface is a mere film, so that when chipped away the innermost coat is seen beneath it, showing that the coats were separate and pyrites was interpolated between them. The evidence, therefore, seems conclusive that the seed belongs to the section Hamamelidoideae of the family Hamamelidaceae. The cast is almost the same size as the perfect seeds of *Hamamelis japonica* Sieb. & Zucc. and of *Fothergilla Gardeni*. But as it now lacks the thick hard coat of the testa, except in one small patch, the perfect seed was probably larger than the seeds of these species; also the faceting of the end is rather broader in the fossil than in the living seeds. Whilst, therefore, we feel confident that the seed should be referred to the Hamamelidaceae, we think it best in the absence of more material, or of any evidence as to the nature of the fruit, to refrain from giving it a generic or a specific name.

V. 22420 Figured Pl. IX, fig. 6. The cast of a seed with remains of the testa. *Reid & Chandler Coll.*, Minster, 1929.

Family LEGUMINOSAE

Genus MIMOSITES Bowerbank

1840. Foss. Fruits London Clay, p. 140.

The specimen described by Bowerbank as *Mimosites Browniana* is still extant, but the preservative with which it has been treated has quite obscured the finer details of structure, if they were ever visible. As it is therefore impossible to add to Bowerbank's diagnoses of genus and species, or to his description, and as we can offer no opinion as to the generic relationship of the fruit, we quote below Bowerbank's original diagnoses and description.

Diagnosis of Genus.—" Fruits which belong to the natural order Mimoseae."

Genotype.—*M. Browniana.*

Mimosites Browniana Bowerbank

1840. *Mimosites Browniana* Bowerbank, p. 140, pl. xvii, fig. 42.
1879. *Mimosites Browniana* Bowerbank: Ettingshausen, p. 396.

Diagnosis.—" *Legume* about six times as long as it is broad: sutures broad and strongly marked: apex acuminate: base attenuated: *seeds* numerous, oval, compressed."

Holotype.—41174.

Description.—" The substance of the legume, unlike the greater number of the Sheppey specimens of fossilized fruits, is composed of carbonaceous matter, and the interior of the fruit appears to be filled with the same material as that in which it is embedded.

" The form and general appearance of this fossil is strikingly similar to the legume of *Vachellia Farnesiana* [*Acacia Farnesiana* Wight & Arne], but the valves appear to have been more compressed, and they do not exhibit any traces of impressions of the numerous, ramifying, vascular bundles, which produce the strongly-marked striated appearance seen over the whole of the surface of the recent fruit. The legumes of a specimen of *Bauhinia candida* in the herbarium of the British

Museum, also resemble our fossil in the proportions of their length and breadth, and are compressed laterally in about the same degree, but the apex of the pod is more acute, and its termination, for about the last half inch of its length, is subulate. The compressed figure of the fossil legume does not appear to be the result of mechanical pressure, as there is not the slightest distortion or fracture in any part of it. This compressed form of the pod also prevails in the fruits of many species of *Acacia*. The seeds are at least eight or nine in number, and present every appearance of being of a similar compressed oval form to those of *Vachellia Farnesiana*, but larger, the form of the one indicated by *a*, fig. 42 [Bowerbank, 1840, pl. xvii], being particularly well displayed.

" Little doubt can remain that this beautiful fossil is either an *Acacia*, or very closely allied to some of the neighbouring genera comprised in the natural group of the *Mimoseae*. I have therefore designated it *Mimosites*."

41174. Figured Bowerbank, 1840, pl. xvii, fig. 42. A legume, 9 cm. in length and 1·3 cm. in breadth, in reddish-brown concretionary cement-stone from Assington, Suffolk. *Colld. by John Brown of Stanway, presd. by Sir R. Owen*, 1860.

Family LINACEAE

Genus WETHERELLIA Bowerbank emend.

1840. Foss. Fruits London Clay, p. 84.

DIAGNOSIS.—Fruit sub-globular or ovoid ; syncarpous, with two to five carpels ; dehiscing septicidally into cocci which subsequently split loculicidally ; locules radially arranged, tangentially compressed ; seeds solitary in each locule ; placentation axile, seeds pendulous by long funicles from below the apex ; pericarp formed of coarse angular parenchyma. Seed almost flat, elongate-obovate ; anatropous, with ventral raphe ; micropyle adjacent to hilum ; testa one-cell thick, formed of polygonal cells.

GENOTYPE.—*W. variabilis* Bowerbank.

Wetherellia variabilis Bowerbank

PLATE IX, figs. 7–22.

1840. *Wetherellia variabilis* Bowerbank (pars), p. 84, pl. xii, figs. 1–5, 8–40.
1879. *Elaeis eocenica* Ettingshausen (pars), p. 393.
1879. *Apeibopsis variabilis* (Bowerbank) Ettingshausen (pars), p. 395.
1879. *Wetherellia variabilis* Bowerbank : Ettingshausen, p. 396.

DIAGNOSIS.—That of the genus.

DESCRIPTION.—*Fruit:* Sub-globular or ovoid with the length equal to, greater than, or less than the diameter, smooth, ribbed, or angled externally ; syncarpous, two- to five-carpelled, two- to five-loculed ; locules radially arranged around the central axis, extending from axis to periphery and base to apex of the fruit, tangentially compressed, and completely flattened along both margins (proximal and distal) but not at the base and apex, slightly inflated where the seed lies (Pl. IX, figs. 17–19) ;

placentation axile, the seeds being suspended by long arched funicles from a point on the axis about one-third or one-quarter of the length of the fruit from the apex (Pl. IX, figs. 17, 18); one-seeded, the seed nearly as long but not so broad as the locule, in which it lies obliquely with the distal end nearer the axis than the proximal end (Pl. IX, figs. 17, 18); dehiscence at first septicidal, through the middle of the thick wedges of tissue between the locules, into as many one-seeded wedge-shaped or hemispherical cocci as there are carpels, the cocci subsequently splitting loculicidally; pericarp formed of three coats: the outer coat thin (usually abraded); the middle coat of angular parenchyma with a few fibro-vascular bundles embedded in its inner face, the bundles branching and anastomosing and ultimately passing into the parenchyma which forms the thick wedge-shaped masses of tissue between the locules, its cells measuring from 0·1 mm. in diameter near the axis to 0·15 mm. at the periphery, all having a general radial alignment; the inner coat, which lines the locule, smooth, formed of delicate straight or sinuous fibres which have a general transverse or oblique alignment (Pl. IX, fig. 18). Length of fruit, 12 to 20 mm.; diameter, 12 to 24 mm.

Seed: Almost flat, elongate-obovate, slightly beaked at the narrow end; anatropous, with hilum terminal at the narrow end (Pl. IX, fig. 18), chalaza small, terminal at the opposite rounded end (Pl. IX, fig. 21), and raphe ventral (Pl. IX, fig. 19); micropyle adjacent to the hilum; testa thin, apparently formed of a single layer of polygonal cells, 0·03 to 0·05 mm. in diameter (Pl. IX, fig. 20). Length of typical seed, 12 mm.; breadth, 3·75 mm.; thickness, 1·5 mm.

REMARKS.—Over 400 specimens, of which about sixty are complete fruits, the remainder being cocci. Bowerbank (1840, p. 84) states that it is perhaps the most abundant of the Sheppey fruits, whilst we ourselves found it in a profusion exceeded only by that of *Nipa*. Bowerbank further remarks that it is known throughout the island by the name of Coffee, to the berries of which some of the detached cocci bear a resemblance. Cocci have also been found recently at Herne Bay by Mr. D. J. Jenkins, and by ourselves.

As seen in the fossil state, this fruit well deserves Bowerbank's specific name *variabilis*. Variations in size, and in the number of locules, produce great differences in its appearance. But the greatest apparent differences are perhaps those due to abrasion after fossilization, whether of the cocci or of the whole fruits. The complete fruits are usually held together, and prevented from falling into their component cocci, by a cement of hard pyrites which has filtered in, prior to dehiscence, along the incipient planes of weakness where septicidal splitting was about to occur. These films of pyrites may form hard ribs on the surface of the fruit (Pl. IX, figs. 7, 9; Bowerbank, 1840, pl. xii, figs. 2, 8, 10). When the exterior of the fruit is abraded, the parenchyma is very liable to be worn. Consequently, where it is thinnest, namely, at the base and apex, and, in a lesser degree over the narrow outer margins of the locules, the locule-casts may be exposed (Pl. IX, figs. 8, 11, 12; Bowerbank, 1840, pl. xii, figs. 1, 3, 9, 13, 19). Such abrasion may be carried so far that the locule-casts may even fall out. Bowerbank believed this to be a form of dehiscence, but we feel sure it is rather a particular state of preservation depending on differences in hardness of the parts of the fruit as fossilized, with resulting differential abrasion after fossilization.

The cocci are either flat (Pl. IX, figs. 13–15) or faceted (Pl. IX, fig. 16) on the ventral surface according as they belong to a two- or more-carpelled fruit ; so that, being convex on the dorsal face, they may be either wedge-shaped or hemispherical. On the ventral face is a median line marking the position of the locule (Pl. IX, fig. 13). As the result of abrasion the narrow locule-cavity is exposed, often with the locule-cast or seed-cast lying within it (Pl. IX, figs. 14–16 ; Bowerbank, 1840, pl. xii, figs. 24–26, 31, 32, 34–36). The cast within, whether that of seed or of locule, is a hard, almond-shaped body formed of pyrites ; if it is a locule-cast, it is often flanged along its lateral margins by a thin flat rim—the cast of that part of the locule beyond the limits of the seed, where the opposed locule walls are almost contiguous. Since the cast is formed of solid pyrites, and the layers of pericarp immediately surrounding it, even when pyritized, which they very rarely are, are much softer, these layers tend to decay and disappear, leaving the hard cast isolated. This would be quite free were it not that the flat marginal flange is gripped between the closely contiguous carpel walls ; but when, as often happens, the almond-shaped cast breaks away from the marginal flange, it becomes quite free and falls out, leaving the locule empty (Pl. IX, figs. 11, 12, 15).

The understanding of this fruit evidently presented the greatest difficulty to Bowerbank. Consequently his account of it is somewhat confused. He recognized that primary dehiscence was septicidal into cocci (his " primary cells ") and that each coccus contained a locule (one of his " secondary cells "). He considered that the cocci were bounded by " dissepiments " and that primary splitting occurred along a plane through the middle of these " dissepiments " which extended from the median placenta to the circumference of the fruit. But these so-called " dissepiments " are merely films of pyrites which have formed along the incipient planes of fracture as described above, while the true carpel wall consists of the " coarse pulpy vegetable tissue " which Bowerbank described as filling the intervening space between the " dissepiments " and the locules. He gives the following account of the locules : " [They] are composed of a single layer of compressed, very minute, cellular tissue, and have their interior surfaces lined with an extremely fine pubescence, the fibres of which . . . are disposed in the direction of lines radiating from the centre of the fruit to its circumference." The so-called pubescence is really the transversely striate locule-lining. Bowerbank made the same mistake when he described the locule-lining of *Hightea* as " down " (cf. p. 449).

In his discussion of the modes of dehiscence of the fruit he distinguished three :

(1) Septicidal dehiscence into cocci.

(2) " The solution of the apex and base of the fruit," a condition of preservation contingent upon fossilization and abrasion, probably not a true mode of dehiscence (cf. p. 252).

(3) Loculicidal dehiscence.

The seeds usually display a certain amount of wrinkling and contraction. The chalaza shows on the internal cast of the testa as a minute prominence (Pl. IX, fig. 21, and base of fig. 20), the cast of the canal for the raphe, the cells being concentrically aligned around it. The raphe is rarely seen, but, when visible, is easily distinguished as a longitudinal strand of fibres lying on the ventral margin of the seed-cast, and associated with the testa. It is usually obscured either by the testa itself or by the pyrites cast of the locule.

Among the fruits of *Wetherellia* belonging to the Bowerbank Collection which are still extant, we have not been able to recognize any of Bowerbank's types, but this is not surprising, as the fruit seems very liable to decay, or to break into cocci, and during the years that have elapsed since his plates were engraved many hundreds of specimens have vanished. Even since we first undertook the investigation of the London Clay fruits, many specimens which were then recognizable as *Wetherellia* in a decaying condition, have disintegrated completely. Nevertheless, there still remain nearly 300 of Bowerbank's specimens. A few fruits were recognized in a jar of *Oncoba* labelled by Ettingshausen " *Cucumites variabilis* Bowerb.," and some specimens of *Wetherellia variabilis*, now decayed, were labelled by Ettingshausen " *Elaeis eocenica* Ett."

Two jars, both labelled by Ettingshausen " *Wetherellia variabilis* Bowerbank," contained respectively fruits of *Cantitilia* (p. 393) and *Lagenoidea* (p. 493), and have been catalogued accordingly.

The following illustrations by Crow in his manuscript catalogue (1810) appear to represent *Wetherellia variabilis:* Nos. 125, 146, BI ?, 225, 321, 322 (a coccus only), 490, 493 ?, 580. One of the specimens figured by Bowerbank as *W. variabilis* (1840, pl. xii, figs. 6, 7) is described (p. 284) as *Euphorbiotheca sheppeyensis* n. sp.

Affinities.—The living allies of this fossil must be sought among families with five- (or fewer) loculed, syncarpous fruits which dehisce both septicidally and loculicidally; which also possess tangentially compressed, one-seeded locules arranged radially; and pendulous anatropous seeds with a ventral raphe, compressed in conformity with the shape of the locules. So far as we have been able to discover, one family only, the Linaceae, shows all these characters in combination. In this family *Hugonia* Linn. is the most comparable genus. It has similar globular, ribbed, or angled fruits, but they are rather smaller than the fossil. *H. mollis* Oliv., from tropical East Africa, is the largest fruit that we have seen. Its diameter, 14 mm., lies well within the range of size of *Wetherellia variabilis*, and compares with a diameter of 15 mm. common in this species. Other species, from India and Ceylon, are smaller, for example, *H. ferruginea* W. & A., length 7 mm., breadth 10 mm.; *H. platysepala* Welw., from tropical Africa, measures 10 mm. in diameter.

The carpels of *Hugonia*, like those of *Wetherellia*, are formed mainly of parenchyma the cells of which are radially aligned and increase in size as they are further from the axis, but the coat is more fibrous than the corresponding coat in *Wetherellia*. The locules in *Hugonia* are similarly arranged, similarly compressed, are lined with a coat of similar character, and extend to the periphery of the fruit; but, when fully developed, the seed occupies more of the locule in *Hugonia* than in *Wetherellia*. In *Hugonia* as in *Wetherellia* the stylar canal is at the apex of the fruit. One of the chief differences between the two fruits lies in their funicles. In *Hugonia* it may arise anywhere between the middle of the axis and a point at about one-sixth of its length from the apex of the fruit; it is not long and arched in its passage from the axis to the hilum, but short and straight. In the position of the hilum, also, *Hugonia* differs from *Wetherellia*. In the former it is sub-apical on the ventral margin, while in *Wetherellia* it is terminal at the apex of the seed. We were able to examine the seed in one living species only. The testa was formed of fine polygonal cells, much finer than those of *Wetherellia*, and the chalaza, although basal, as in the fossil, formed a large conspicuous scar.

In view of the evidence given above, we think it probable that *Wetherellia* Bowerbank belongs to the family Linaceae, and that it is related to *Hugonia*. At the same time we cannot place it in that genus because of the differences noted above. We have therefore retained Bowerbank's generic name. The genus *Hugonia* belongs to the tropics of Asia, Africa, Australia, and New Caledonia.

V. 22421 Figured Pl. IX, fig. 7. A multilocular fruit, much abraded on one side, but unusually perfect on the other, as shown in fig. 7.
V. 22422 Figured Pl. IX, fig. 8. A 5-loculed fruit, abraded at the end so that the locule-cavities are exposed (as they are also in V. 22423, 22425, and 22426).
V. 22423 Figured Pl. IX, fig. 9. A 3-loculed fruit.
V. 22424 Figured Pl. IX, fig. 10. A 4-loculed fruit.
V. 22425 Figured Pl. IX, fig. 11. A 3-loculed fruit.
V. 22426 Figured Pl. IX, fig. 12. A 2-loculed fruit.
V. 22427 Figured Pl. IX, fig. 13. An almost perfect coccus from a 2-loculed fruit.
V. 22428 Figured Pl. IX, fig. 14. A somewhat abraded coccus, with the locule and seed-cast partly exposed on the ventral surface.
V. 22429 Figured Pl. IX, fig. 15. A greatly abraded coccus from which the seed-cast has dropped out of the locule.
V. 22430 Figured Pl. IX, fig. 16. A coccus from a fruit with more than two locules (? four), hence the ventral surface is faceted, not flat as in the preceding.
V. 22431 Figured Pl. IX, fig. 17. A fruit, fractured longitudinally; it shows clearly the placentation, and the relatively small part of the locule occupied by the seed.
V. 22432 Figured Pl. IX, fig. 18. A fruit, fractured longitudinally. It shows the lining of the locule and the placentation of the pendulous seeds.
V. 22433 Figured Pl. IX, fig. 22. A worn fruit, fractured and figured to show the coarse tissue of the carpel wall.
V. 22434 Figured Pl. IX, fig. 19. A coccus, fractured loculicidally so as to expose the locule and the seed-cast. The ventral raphe is clearly seen in this specimen.
V. 22435 Figured Pl. IX, fig. 20. A seed-cast showing the micropyle and chalaza.
V. 22436 Figured Pl. IX, fig. 21. A worn fruit, broken longitudinally; on one of the contained seed-casts the chalaza can be seen clearly.
V. 22437 Nine good fruits or cocci; various sizes, and various stages of abrasion.
V. 22438 A coccus fractured loculicidally. The contained seed-cast shows the raphe.
V. 22439 Forty-eight fruits, more or less abraded. A few of these were in a jar containing *Oncoba* fruits (*Cucumites* of Bowerbank), labelled by Ettingshausen "*Cucumites variabilis* Bowerb."
V. 22440 100 cocci or broken fruits.
V. 22441 Twenty-eight specimens, fruits or cocci. Each has been fractured longitudinally and has a counterpart.
V. 22442 A dehisced fruit, cocci much abraded.
V. 22443 Five fruits or cocci (dehisced). Labelled by Ettingshausen "*Faboidea* Bowerbank."
All the above are from the Bowerbank Coll., Sheppey.
V. 22444 Thirty cocci. *Reid & Chandler Coll.*, between Minster and Warden, 1928.
V. 22445 Eighty-five cocci and one fruit. *Reid & Chandler Coll.*, Minster, 1929.
V. 22446 A coccus collected at Herne Bay, below the west cliff. *Reid & Chandler Coll.*, 1930.

Family LINACEAE ?

Genus DECAPLATYSPERMUM nov.

DIAGNOSIS.—Fruit sub-globular, syncarpous, ten-loculed, with one pendulous seed in each locule; locules compressed tangentially; axis of fruit thick and fibrous. Seeds elongate-oval, ventral margin almost straight, dorsal margin probably convex; anatropous, hilum terminal at one end of the ventral margin (marked by a slight hook), chalaza terminal at the opposite end, raphe ventral; testa puckered externally and formed of transversely elongate cells.

GENOTYPE.—*D. Bowerbanki.*

Decaplatyspermum Bowerbanki n. sp.

PLATE IX, figs. 23–29.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22447.

DESCRIPTION.—*Fruit:* Sub-globular, with a shallow, circular, depressed area of attachment at the base, syncarpous, ten-loculed, with one seed in each locule; locules much compressed tangentially, arranged radially around a thick fibrous axis which is thicker at the two extremities than in the middle, so that the inner edges of the locules are convex towards the axis; seeds pendulous from the apex of the locules; pericarp thick and woody, formed of rather loose tissue; lining of the locules formed of transversely elongate cells. Length of fruit (as preserved), 9·5 mm.; diameter, 10·6 mm.

Seed: Elongate-oval in outline, the ventral margin straight or slightly convex and slightly hooked at the hilar end, the dorsal margin probably convex (as inferred from the general form of the fruit), but now much worn, laterally compressed, more inflated at the chalazal than at the hilar end; anatropous, with hilum at the narrow end of the ventral margin, chalaza at the rounded end, and raphe ventral, where it forms a marginal thickening; micropyle adjacent to the hilum; testa formed of three coats: the outer somewhat puckered (Pl. IX, fig. 29) formed of elongate cells (from 0·016 to 0·025 mm. in diameter) with bevelled edges, which are transversely aligned over the lateral faces, longitudinally aligned along the raphe, and follow the general curvature of the margin at the chalazal end; the middle coat formed of small cells the outlines of which cannot be clearly seen; the inner coat of small close-set square or polygonal cells (about 0·008 mm. in diameter) which form concentric rings around the micropyle. Length, 8·5 to 9 mm.; breadth, 3·5 to 4 mm.

REMARKS.—One much abraded specimen. The pericarp has been worn away except at the base and apex, and between the locules, where it has been protected by the hard pyrites locule-casts. A seed is exposed in each locule surrounded by the remains of the locule-cast. Some of the locules enclose mature seeds from which the carbonaceous testa is worn away over the dorsal margin, but still remains over the lateral surfaces where it has been preserved between the hard locule- and seed-casts (Pl. IX, figs. 24, 25). In other locules the seeds are immature, there is no seed-cast, and only the worn-down edges of the collapsed testa can be seen lying within hollows in the locule-casts (Pl. IX, fig. 23). As viewed from the exterior, the specimen presents an alternating series of ridges and hollows. At the centre of each carpel is the worn-down seed itself, or a cavity in which it formerly lay; this is flanked on each side by a pyrites ridge, the lateral portions of the locule-cast seen in section; and again flanking the locule-cast are hollows left by the abraded septa. This combined effect of pyritization and abrasion is very peculiar, and at first we were quite at a loss to interpret the structure of the specimen. We were, therefore, obliged to fracture it longitudinally, whereupon we discovered the characters described above.

Affinities.—Syncarpous fruits with ten one-seeded, tangentially compressed locules and with pendulous anatropous seeds with ventral raphe are very rare. The only family in which we can find all these characters combined is the Linaceae, where the normal number of locules may be doubled by the development of false septa between the pairs of seeds, so that a normally five-loculed fruit may become ten-loculed. We have compared the fruit with that of *Hugonia* Linn. The arrangement of the locules around the thick, somewhat hour-glass-shaped fibrous axis is the same, and the shape of the locules is very similar. We have only been able to examine the seeds of one species, and in that species the structure of the testa was very different from that seen in the fossil.

Owing to the very worn condition of the fossil fruit, the information regarding it is far from complete. Whilst therefore suggesting that it may be related to the Linaceae, we cannot feel certain that it belongs to that family.

V. 22477 Holotype, figured Pl. IX, figs. 23–29. An abraded fruit, now fractured into several pieces to show the structure. *Bowerbank Coll.*, Sheppey.
V. 22477*a* Pl. IX, figs. 25, 26. A fragment of the fruit, showing the stout axis and the remains of the carpel wall at the apex.
V. 22477*b* Pl. IX, fig. 27. An impression of a seed with remains of testa.
V. 22477*c* Pl. IX, fig. 28. Pyrites cast of a locule showing the form of the seed (seen as an impression with adherent remains of the testa).
V. 22477*d* Pl. IX, fig. 29. A well-preserved impression of the external surface of a seed, showing the crumpling and the transversely elongate cells.

Family RUTACEAE

Genus CANTICARYA nov.

Diagnosis.—A form-genus belonging to the Rutaceae. Fruits syncarpous, capsular. Mature carpels one-seeded, inflated but somewhat compressed laterally, with convex dorsal and straight or slightly convex ventral margin, bisymmetric, dehiscing into two valves in the plane of symmetry; endocarp formed of long cells or fibres. Seed pendulous, conforming in general shape to the carpel; anatropous, with the large elongate hilum on the ventral margin, ventral raphe, and large circular basi-dorsal chalaza; outer surface of testa formed of polygonal cells; tegmen formed of elongate cells.

GENOTYPE.—*C. sheppeyensis* n. sp.

Canticarya sheppeyensis n. sp.

PLATE X, figs. 1–5.

DIAGNOSIS.—Carpels sub-ovoid, dorsal margin gibbous, ventral margin slightly convex: Seed, length, 6 to 6·6 mm.; breadth, 5·5 mm.; thickness, 4 to 5 mm.

HOLOTYPE.—V. 22448.

DESCRIPTION.—*Fruit:* Syncarpous, with one developed seed in each locule. Carpels sub-ovoid, somewhat compressed laterally, dorsal margin gibbous, ventral margin slightly convex (a form permitting partial fusion with other carpels), bisymmetric, dehiscing into two valves along the plane of symmetry; style apical on the ventral margin; exocarp smooth (about 0·3 or 0·4 mm. thick), formed of parenchyma, the cells (about 0·025 mm. in diameter, but obscure) having a tendency to radial arrangement; endocarp formed of elongate cells or fibres (about 0·025 mm. broad) directed obliquely from the ventral margin (Pl. X, fig. 2); the locule is lined by elongate or oblong cells 0·012 to 0·016 mm. in breadth; superposed on its surface are the clearly defined impressions of the polygonal cells of the testa.

Seed: Pendulous from the apex of the fruit, conforming in general shape to the carpel, the plane of symmetry passing through hilum and chalaza; anatropous, with hilum large and long on the ventral margin (Pl. X, fig. 3), chalaza circular and large (Pl. X, fig. 5), basi-dorsal, raphe short, ventral; testa formed of an outer coat of polygonal cells, 0·025 to 0·05 mm. in diameter (the impressions of which are seen on the locule lining), and an inner coat of elongate cells, 0·002 to 0·016 mm. broad, which diverge from the chalaza to become longitudinally aligned (Pl. X, fig. 5); one specimen shows beneath this a surface with impressions of elongate cells, 0·001 mm. in breadth; another shows in addition a network of furrows and loops indicating either fibres or folded cotyledons.

REMARKS.—Twelve specimens, all much abraded, but enough remains of the pericarp to show the form and structure. The almost straight ventral margin indicates the union of two or more carpels by their ventral margins. Dehiscence in the plane of symmetry is clearly shown by the infiltration of pyrites (Pl. X, fig. 4). The pericarp and testa have suffered much abrasion, especially over the chalaza, which is frequently exposed (Pl. X, fig. 5). The shape of the hilum is shown by its impression on the locule-cast (Pl. X, fig. 3).

AFFINITIES.—The shape of the fruit, with slightly convex ventral margin, the mode of dehiscence, the character of the pericarp, and the character and position of the various organs of the anatropous seed, especially of the chalaza, all place this species, beyond a doubt, in the Rutaceae. In this family the endocarps are fibrous and horny and usually split, either wholly or partially, into symmetric halves. We have been unable to relate the fossil to any one living genus; therefore we have placed it in a form-genus, *Canticarya*, under the name *C. sheppeyensis*.

V. 22448 Holotype, figured Pl. X, figs. 1, 2. A seed with remains of pericarp adhering to it. The specimen shows the locule-cast and part of the endocarp, the coats of the testa and the large chalaza. *Bowerbank Coll.*, Sheppey.

V. 22449 Figured Pl. X, fig. 3. A locule-cast showing the placental scar, which agrees in size and shape with the hilum. Hence the specimen reproduces accurately the external form of a perfect seed. *Reid & Chandler Coll.*, Minster, 1928.

V. 22450 Figured Pl. X, fig. 4. A pericarp (now detached) and locule-cast. Pyrites evidently filled a gap between the dehiscing margins of the carpellary valves, and later abrasion of the softer carbonaceous walls left a ridge of pyrites. The surface of the specimen shows impressions of the polygonal cells of the testa. *Bowerbank Coll.*, Sheppey.

V. 22451 Figured Pl. X, fig. 5. A seed-cast showing chalaza and raphe. The cells of the tegmen are radially arranged round the chalaza. The remains of the pericarp are preserved on the ventral margin. A system of curved grooves on the seed-cast may indicate fibres or folds of cotyledons. Labelled by Ettingshausen " *Faboidea* Bowerb." *Bowerbank Coll.*, Sheppey.

V. 22452 A fruit with remains of pericarp on the ventral margin, and, within, the internal cast of a seed. *Bowerbank Coll.*, Sheppey.

V. 22453 A locule-cast broken in two. *Reid & Chandler Coll.*, Minster, 1928.

V. 22454 Five casts of locules or seeds. *Reid & Chandler Coll.*, Minster, 1929.

V. 22455 Internal cast of a seed with remains of pericarp. *Bowerbank Coll.*, Sheppey.

Canticarya ventricosa n. sp.

Plate X, figs. 6, 7.

Diagnosis.—Carpels dorsally ventricose, ventral margin straight; length of straight margin of a small carpel, 3·5 mm.; dorsi-ventral diameter, 6·5 mm.; length of ventral face of large seed, 4·5 to 5·5 mm.; dorsi-ventral diameter, 6 to 7·5 mm.; thickness, 4 to 4·5 mm.

Holotype.—V. 22456.

Description.—*Fruit:* Syncarpous, with one developed seed in each locule. Carpels bisymmetric, and somewhat compressed laterally, dorsal margin ventricose, ventral margin straight (indicating at least two carpels united in some degree along this margin, Pl. X, fig. 7), dehiscing along the plane of symmetry (shown by a dorsal ridge of pyrites); pericarp formed of an outer coat of parenchyma, and an inner coat of fibres aligned obliquely from the ventral margin. The surface of the locule-cast bears also the impression of the cells of the testa (Pl. X, fig. 6). Length of straight ventral margin of a small carpel, 3·5 mm.; dorsi-ventral diameter, 6·5 mm.

Seed: Conforming in general shape to the locule, the plane of symmetry passing through the hilum and chalaza, anatropous, with the large elongate hilum on the ventral margin; chalaza large and circular, 2·5 mm. in diameter, and raphe ventral; micropyle apical on the ventral margin; testa thin, formed of an outer coat of polygonal cells (0·05 to 0·075 mm. in diameter) and an inner coat of elongate cells (0·016 mm. in breadth) longitudinally aligned, which converge to the chalaza (seen on internal casts of seeds). Length of ventral margin of a large seed, 4·5 to 5·5 mm.; dorsi-ventral diameter, 6 to 7·5 mm.; thickness, 4 to 4·5 mm.

Remarks.—Eight specimens; one of these (Pl. X, fig. 7), which has a surface highly polished by friction so that no cell-structure can be seen, is otherwise in a more or less perfect condition. A second worn specimen (holotype) shows part of the two coats of the pericarp and the impressions of the large polygonal cells of the testa on the locule-cast, also the cells of the inner coat of the testa (Pl. X, fig. 6).

Another broken specimen shows small fragments of the endocarp and the two coats of the testa (but not their thickness). In the hope of obtaining more information, two other specimens were fractured, but proved to be merely internal casts of the locule, with scarcely a trace of the cells either of endocarp or of testa. A specimen labelled " *Faboidea* " by Ettingshausen showed the testa and part of the pericarp very clearly.

AFFINITIES.—This species is not so fully known as *Canticarya sheppeyensis* (p. 258), but the correspondence of all the coats in the two species is so close that we think they probably belong to a single genus. In the absence of further information regarding both fossil and living fruits we have been obliged to refer them to the form-genus *Canticarya*. There is, however, so consistent a difference in form between *C. sheppeyensis* and *C. ventricosa* that they must be referred to different species; moreover, the two specimens of *C. ventricosa* which show the chalaza suggest that it was rather larger in this species than in *C. sheppeyensis*.

V. 22456 Holotype, figured Pl. X, fig. 6. Locule-cast with remains of the pericarp and, within, the seed. *Bowerbank Coll.*, Sheppey.

V. 22457 Figured Pl. X, fig. 7. Carpel, much polished by friction. *Reid & Chandler Coll.*, Minster, 1929.

V. 22458 Cast of seed, with remains of pericarp showing attachment. Labelled by Ettingshausen " *Faboidea* Bow." *Bowerbank Coll.*, Sheppey.

V. 22459 Much worn cast of locule and seed, now fractured. Labelled by Ettingshausen " *Faboidea*." *Bowerbank Coll.*, Sheppey.

V. 22460 Much worn cast of locule and seed, now fractured, another cast of a locule and seed, also a much worn carpel with locule-cast. *Reid & Chandler Coll.*, Minster, 1929.

V. 22461 Abraded carpel enclosing seed. Labelled by Ettingshausen " *Faboidea*." *Bowerbank Coll.*, Sheppey.

Canticarya ovalis n. sp.

PLATE X, figs. 8, 9.

DIAGNOSIS.—Carpels ovoid, ventral margin somewhat convex, dorsal margin highly convex; length from apex, 7·3 mm.; dorsi-ventral diameter, 6 mm.; thickness, 4 mm. Seed: length from apex, 6·5 mm.; dorsi-ventral diameter, 5·5 mm.; thickness, 3 mm.

HOLOTYPE.—V. 22462.

DESCRIPTION.—*Fruit:* With one seed in each locule. Each carpel bisymmetric, ovoid, somewhat laterally compressed. Ventral margin somewhat convex, dorsal margin highly convex. Endocarp formed of two coats; external thick coat of polygonal cells (from 0·016 to 0·025 mm. in diameter) arranged in a more or less columnar manner. Within is a thin fibrous coat about three cells thick, the fibres curving from the ventral margin to a point corresponding to that of the chalaza on the seed. As in the two species of *Canticarya* previously described, the inner surface of this coat bears the impressions of the large polygonal cells of the testa. Length of carpel from the apex, 7·3 mm.; dorsi-ventral diameter, 6 mm.; thickness, 4 mm.

Seed: Conforming in shape to the locule; the plane of symmetry passing through hilum and chalaza. Anatropous, with ventral hilum, circular basi-dorsal chalaza about 1·5 mm. in diameter, and short ventral raphe; testa thin, formed of an outer coat of polygonal cells (0·025 to 0·05 mm. in diameter), and an inner coat of oblong cells (about 0·016 mm. broad), aligned longitudinally and giving rise to longitudinal striations which radiate from the chalaza. Length from apex, 6·5 mm.; dorsi-ventral diameter, 5·5 mm.; thickness, 3 mm.

Affinities.—Three specimens. The form and structure of the fruit and seed, and the arrangement of the various seminal organs indicate, as in the preceding species, a relationship to Rutaceae. This fossil species must also be referred to the form-genus we have described as *Canticarya*. It differs from *C. sheppeyensis* and *C. ventricosa* in having the parenchymatous coat of the pericarp thicker and the fibrous endocarp thinner than in those species. Again the form of the endocarp is somewhat different; the ventral margin is more convex than in those species so that the carpel is more ovate in outline. In view of this character we have named it as a separate species, *Canticarya ovalis*.

V. 22462 Holotype, figured Pl. X, figs. 8, 9. A carpel, fractured so as to expose the internal cast of the seed and the thickness of the carpel wall. *Reid & Chandler Coll.*, Minster, 1929.

V. 22463 Two specimens (one fractured), casts of locules and seeds. *Reid & Chandler Coll.*, Minster, 1929.

Canticarya gracilis n. sp.

Plate X, fig. 10.

Diagnosis.—Carpel sub-ovoid, ventral margin slightly convex, dorsal margin semicircular. Seeds agreeing with the carpels in shape. Length of seed, 4·16 mm.; breadth, 2·75 mm.

Holotype.—V. 22464.

Description.—*Carpel:* One-loculed, with a pendulous seed. Sub-ovoid with ventral margin slightly convex in outline, dorsal margin semicircular, slightly compressed from side to side, bisymmetric, splitting into two valves in the plane of symmetry. Pericarp (as preserved) about 0·6 mm. thick, formed of a thick coat of parenchyma and an inner thin coat of fibres or elongate cells (endocarp) a few layers thick. The locule lining is smooth and shining and shows on its surface the superimposed impressions of at least two of the fibrous layers. In one of these layers the cells diverge obliquely from a dorsal groove and in the other from the base of the locule. The placenta is on the ventral margin near the top of the locule. The carpel is too abraded and fragmentary for measurement.

Seed: Bisymmetric, conforming in shape to the locule, slightly compressed laterally, anatropous, with the long, narrow, hilar scar on the ventral margin. Raphe ventral, chalaza large, circular, basi-dorsal (Pl. X, fig. 10), testa formed of polygonal cells about 0·03 mm. in diameter. Length of seed, 4·16 mm.; breadth, 2·75 mm.

Remarks and Affinities.—One specimen. Most of the pericarp was broken or abraded so as to expose the locule-cast. No organs were at first visible so that we could not tell whether we were dealing with a locule-cast or seed. We therefore ventured to break the cast and thereby exposed the seed with characteristic testa and chalaza. It was then evident that the specimen must be referred to the Rutaceae and to the form-genus *Canticarya*. It is unlike any species of that genus previously described both in form and size.

V. 22464 Holotype, figured Pl. X, fig. 10. A seed with remains of carpel. *Bowerbank Coll.*, Sheppey.

Genus SHRUBSOLEA nov.

DIAGNOSIS.—Seed sub-ovoid, straight, and faceted at the ventral margin over the large oval hilar scar, anatropous, with a large chalaza at the rounded end; testa hard and woody, formed of a thick outer coat of parenchyma and a thin inner coat of longitudinally aligned oblong cells; length of the straight margin, 6 mm.; dorsi-ventral diameter, 10·5 mm.

GENOTYPE.—*S. Jenkinsi* n. sp.

Shrubsolea Jenkinsi n. sp.

PLATE X, figs. 11, 12.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22465.

DESCRIPTION.—*Seed:* Sub-ovoid, flattened somewhat on one side, faceted along the ventral margin, on which is the large oval hilar scar bisected longitudinally by the marginal angle; anatropous, with ventral hilum and raphe and large semi-lunar chalaza at the rounded end; testa relatively thin, hard and woody (shown by the lack of compression), the outer coat (thickened over the raphe) of close polygonal cells, 0·016 to 0·025 mm. in diameter; the inner coat (tegmen ?) thin and finely striate, of small oblong cells (0·016 mm. in breadth) longitudinally aligned. Length of straight margin, 6 mm.; dorsi-ventral diameter, 10·5 mm.; thickness, 7 mm.

REMARKS AND AFFINITIES.—One perfect seed. The shape, together with the shape and position of the hilar scar, are so characteristic of the Rutaceae, that we felt justified in chipping away a small portion of the testa at the rounded end in order to verify the determination by the discovery of the chalaza, which was thereby exposed in the position characteristic of the section Ruteae. The structure of the testa was also thus exposed and bears out the relationship. The flattening on one side of the hilum suggests that the specimen was one of a pair of developed seeds. It is larger than the seeds in most comparable living species, but does not exceed the possible size-limit, for a few genera have seeds even larger. We have named it *Shrubsolea* after one of the earlier collectors of Sheppey fossils, W. H. Shrubsole, the discoverer of diatoms in the London Clay.

V. 22465 Holotype, figured Pl. X, figs. 11, 12. *D. J. Jenkins Coll.*, Herne Bay.

Genus EOZANTHOXYLON nov.

DIAGNOSIS.—Fruit capsular (plurilocular and syncarpous ?). Carpel one-seeded, dehiscing symmetrically into two valves; outer surface with large circular glands; locule-lining formed of cells with sinuous arrangement. Seed gibbous dorsally, straight ventrally; anatropous, with dorsal chalaza (?); testa formed of an outer layer of irregular polygonal cells and five inner layers of finer polygonal cells.

GENOTYPE.—*E. glandulosum* n. sp.

Eozanthoxylon glandulosum n. sp.

Plate X, figs. 13, 14.

Diagnosis.—That of the genus.

Holotype.—V. 22466.

Description.—*Fruit:* Capsular (plurilocular and syncarpous ?). Carpel subglobular with a short, straight ventral margin, dehiscing and gaping along the dorsal margin (Pl. X, fig. 13); style apical on the dorsal margin; surface conspicuously dotted with large circular glandular pits about 0·4 mm. in diameter; pericarp formed of large fusiform or oblong cells radially aligned towards the periphery, but variously aligned towards the locule, so as to give rise to sharp conspicuous sinuosities and torsions; locule-lining smooth, formed by sinuous cells (about 0·05 mm. broad and frequently two or three times as long). Length of fruit, 9 mm.; dorsi-ventral breadth, 8 mm.; thickness, 7 mm.

Seed: Probably gibbous in outline, with a straight ventral margin bearing a long hilar scar, and somewhat compressed laterally; anatropous ? chalaza probably at the middle of the dorsal margin, as indicated by a concentric arrangement of the cells of the testa in that part; micropyle almost certainly apical on the ventral margin, as indicated by a slight mucro from which the cells of the testa radiate; testa about 0·1 mm. thick, formed of a superficial layer of irregular polygonal cells of very variable size and shape, which may measure from 0·05 to 0·1 mm. in diameter, but around the chalaza and micropyle are more elongate (about 0·03 mm. long, and 0·01 mm. broad), and about five inner layers of irregular polygonal cells approximately 0·016 mm. in diameter. As seen in section the testa seems to be discontinuous over the hilar scar. Length of seed, 5 mm.; breadth, 4·5 mm.

Remarks.—One specimen, consisting of the broken, detached pericarp, and the locule-cast enclosing the seed. We were able to patch these fragments together in position over the locule-cast (Pl. X, fig. 13), thus obtaining evidence of a carpel dehiscing along the dorsal margin; the straight ventral margin probably indicates that the carpel was fused with others, hence that the fruit was syncarpous and plurilocular. On the surface of the carpel are seen the conspicuous glandular pits (Pl. X, fig. 13); and, on its inner surface, also on the surface of the locule-cast, the large sinuous cells of the locule-lining.

Affinities.—The shape, mode of dehiscence, glandular pericarp, as well as the apparent position of micropyle and chalaza all suggest that the fossil belongs to the Rutaceae. Similar glands occur in the epicarp of *Zanthoxylon* and other genera of the section Zanthoxyleae. The name *Eozanthoxylon* is used to indicate relationship with the section, not with the genus.

V. 22466 Holotype, figured Pl. X, figs. 13, 14. A broken carpel enclosing a locule-cast and seed. *Bowerbank Coll.*, Sheppey.

Genus CLAUSENISPERMUM nov.

Diagnosis.—Seeds sub-ovoid, pointed, angled along the ventral margin, anatropous, hilum at the pointed end, raphe ventral, branching from the end opposite the hilum (chalaza ?) to form a network of coarse fibres.

GENOTYPE.—*C. dubium* n. sp.

Clausenispermum dubium n. sp.

PLATE X, figs. 15, 16.

1879. *Apeibopsis variabilis* (Bowerbank) : Ettingshausen (pars), p. 395.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22467.

DESCRIPTION.—*Seed :* Sub-obovoid, with an obscure ventral angle ; anatropous, with the hilum terminal at the pointed end and raphe ventral ; on reaching the broad end the raphe turns back, branching and anastomosing over the whole surface in the direction of the hilum, the branching on both sides of the seed being similar ; testa formed of parenchyma (cells obscure) ; its internal cast is smooth and glistening and shows the impression of obscure oblong or angular cells (tegmen ?) with transverse alignment. Length of seed, 5 mm. ; greatest breadth, 3·2 mm. ; least breadth, 2·5 mm.

AFFINITIES.—Two seeds in a jar with other genera labelled by Ettingshausen "*Apeibopsis variabilis* Bow." He evidently mistook them for seeds of *Oncoba* (p. 407), which they somewhat resemble in size and superficial appearance.

The size and form of the seeds, the position of the hilum, the peculiar branching raphe, and the character of the testa, taken together, point to a relationship with the section Limoniinae (Engler) of the family Rutaceae. The fossils most resemble species of *Clausena* Burm. But the seeds of other allied genera may be similar. Hence, without more material and more knowledge of living and fossil species we think it undesirable to place the fossils in the genus *Clausena*, and have given them a new generic name, *Clausenispermum*, to indicate their relationship.

The whole section Limoniinae is found in the tropics of eastern Asia and Africa. The genus *Clausena* is a native of the Indo-Malayan region and of tropical and south Africa.

V. 22467 Holotype, figured Pl. X, fig. 15. A seed showing clearly the branching raphe.
V. 22468 Figured Pl. X, fig. 16. A second seed, it shows the lining of the testa (cast).
Both are from the Bowerbank Coll., Sheppey.

Family RUTACEAE ?

Genus CAXTONIA nov.

DIAGNOSIS.—Carpel ovoid, somewhat laterally compressed, one-celled, one-seeded, dehiscent (?), formed of woody parenchyma without, and transverse or oblique fibres within. Seed anatropous, with the large sub-oval chalaza (sometimes ridged across) at the broad end ; testa formed of a coat, several layers thick, of polygonal secreting cells 0·1 to 0·15 mm. in diameter, on each side of which is a single layer of polygonal cells 0·025 mm. in diameter ; tegmen longitudinally striate.

GENOTYPE.—*C. glandulosa* n. sp.

Caxtonia glandulosa n. sp.

Plate X, figs. 17–19.

1879. *Apeibopsis variabilis* Bowerbank (pars): Ettingshausen, p. 395.

Diagnosis.—Carpel ovoid, outer coat of pericarp formed of compact parenchyma. Seed placed centrally in the fruit. Length of fruit, 7·5 mm.; breadth, 7 mm. Inner and outer layers of testa formed of cells 0·025 mm. in diameter. Length of seed, 4 to 5·5 mm.; breadth, 4 to 4·5 mm.

Holotype.—V. 22469.

Description.—*Carpel:* Ovoid, somewhat laterally compressed, slightly asymmetric, one margin being usually more convex than the other; one-celled, one-seeded, the seed placed centrally in the fruit; dehiscent (?); outer coat formed of compact parenchyma with cells radially aligned; inner coat formed of transverse fibres. Length of fruit, 7·5 mm.; breadth, 7 mm.; thickness, 5·5 mm.

Seed: Obovoid, with rounded base scarcely truncate; anatropous, with the raphe, a stout cord of fibres, lateral, the large sub-oval chalaza, sometimes with a median longitudinal ridge (Pl. X, fig. 19) at the broad end of the seed, and the micropyle at the narrow end; testa (as much as 0·4 mm. thick) formed of a few layers (two or four ?) of large secreting polygonal cells, 0·1 to 0·15 mm. in diameter (Pl. X, fig. 18), containing a black glistening substance (resin or oil ?); on each side of this coat are the remains of thin coats overlying and underlying it, the polygonal cells of both having the same diameter (0·025 mm.). On the inner side the coat itself is sometimes preserved, on the outer side, the impressions only. These thin coats may imply that the large cells were formed by the breaking down of many small cells; tegmen formed of long cells 0·012 to 0·016 mm. broad, attenuate or truncate at their ends, which form a longitudinally striate surface, the striations radiating from the margin of the chalaza. Length of seed, 4 to 5·5 mm.; breadth, 4 to 4·5 mm.

Remarks and Affinities.—Twelve specimens. The characters of endocarp and seed suggest very strongly that the alliance of this species is with the Rutaceae, although we have found no genus with exactly the same succession of coats. We have therefore placed it doubtfully in the family under the name *Caxtonia glandulosa*, after the Kentish worthy, Caxton the printer, born 1422.

V. 22469 Holotype, figured Pl. X, fig. 17. A fruit with seed, now fractured. It shows the pericarp, the secreting cells of the testa, the cast of the layer inside, the tegmen and chalaza.
V. 22470 Figured Pl. X, fig. 18. A seed showing the coarse secreting cells very clearly.
V. 22471 Figured Pl. X, fig. 19. A seed and remains of pericarp. The seed, which shows the chalaza clearly, is fractured longitudinally.
V. 22472 A seed with fragments of fruit.
V. 22473 Seven fruits or seeds variously abraded.
V. 22474 A seed with remains of the pericarp, probably referable to this species.
The above are all Reid & Chandler Coll., Minster, 1929.
V. 22475 An imperfect seed-cast; in a jar with other genera labelled by Ettingshausen "*Apeibopsis variabilis* Bow." *Bowerbank Coll.*, Sheppey.

Caxtonia rutacaeformis n. sp.

PLATE X, figs. 20–23.

DIAGNOSIS.—Carpel ovoid, outer coat of pericarp formed of elongate cells. Seed placed nearer the apex than the base of the fruit. Length of carpel, 9·5 mm.; breadth, 7·3 mm. Inner and outer layers of testa formed of equiaxial cells 0·03 mm. in diameter. Length of seed, 5·75 mm.; breadth, 5·5 mm.

HOLOTYPE.—V. 22476.

DESCRIPTION.—*Carpel:* One-loculed, one-seeded, the seed placed nearer to the apex than to the base, ovoid but somewhat compressed laterally. The pericarp has two coats. The outer is about 0·8 mm. thick, formed of rather large elongate cells. Within is a coat of fibres which are aligned horizontally from a median line along one margin and sweep obliquely upwards as they pass around the locule, thus meeting along the opposite margin at acute upward-directed angles. The trend of these fibres indicates that the endocarp probably dehisced along both margins. Length of carpel, 9·5 mm.; breadth, 7·3 mm.

Seed: Sub-triangular in outline (the hilar end being pointed and the chalazal end broadly truncate), oval in section (Pl. X, figs. 22, 23), anatropous, with hilum and chalaza marginal at opposite ends, and raphe lateral. The chalaza is elongate-oval with a transverse ridge (Pl. X, fig. 23). The testa appears to have been formed of three coats: An outer coat apparently one cell thick (seen only as an impression of equiaxial cells measuring 0·03 mm. in diameter); within is a coat, also one cell thick, of large hexagonal cells, 0·1 mm. or rather more in diameter, which contain a shining black secretion; the third coat is formed of equiaxial cells 0·03 mm. in diameter (seen only as an impression on the surface of the large cells). Length of seed, 5·75 mm.; breadth, 5·5 mm.

REMARKS AND AFFINITIES.—One specimen. The form of the carpel, the character of the endocarp, the form of the seed, and the position and form of the chalaza suggest relationship with the Rutaceae. The coarse secreting cells of the testa suggest generic relationship with *Caxtonia glandulosa*. We have therefore named the specimen *Caxtonia rutacaeformis*.

V. 22476 Holotype, figured Pl. X, figs. 20–23. A fruit, fractured to show the seed. *Bowerbank Coll.*, Sheppey.

Family BURSERACEAE

The fruits of the Burseraceae, taken as a whole, form a remarkably homogeneous group, and in consequence, members of the family can often be recognized readily, even when they can no longer be matched exactly among living genera.

The structure of the endocarp, so far as we have been able to observe it, is highly characteristic. It is formed of three distinct coats: An outer thick coat of equiaxial cells; a median coat, one cell thick, of uniform hexagonal cells; and an inner compact coat several cells thick, the cells being polygonal and having a tendency to be arranged in transverse rows. This succession appears to persist throughout the family.

The fruits are syncarpous; the carpels vary in number and form, and often all but one are abortive. A central, axile canal runs from the base to the apex; it carries a fibro-vascular strand from the attachment to the placentas. At a distance which varies from one-sixth to one-half the length of the fruit from the apex this strand branches, each branch forming a short funicle which passes through the ventral wall of a carpel into the locule where it forms two placentas, to each of which is attached a pendent ovule, although only one seed comes to maturity. In this family the locules when fully developed lie symmetrically around the axis, and are radially compressed, the symmetry being destroyed when, as frequently happens, some of the locules are abortive. Germination occurs by the removal of large valves from the dorsal faces of the carpels. The funicle in Burseraceae is short or almost wanting; consequently the hilum is closely adjacent to the placenta. The chalaza may be heart-shaped or sub-triangular, or a transverse arched band of fibres. It is sometimes separated from the hilum by a short raphe. The micropyle is terminal, directed towards the apex of the fruit.

Upon the evidence afforded by fruits alone it is not always easy to distinguish between different genera. Only a small amount of living material is available for dissection; hence we have not always been able to discover the limits of variation in certain similar genera, although the characteristics of a number of species belonging to each may have been ascertained. Thus it is difficult to distinguish between *Commiphora* Jacq. and *Bursera* Jacq. On the other hand, *Canarium* (Rumph.) Linn. appears to be very uniform and distinctive in its generic features.

On the basis of these general characters the fossil species about to be described can without hesitation be referred to the family Burseraceae, but we have been unable to place them in living genera. Two are well represented, so that their characters are very completely known. These indicate that they belong in all probability to different genera, and that they differ from any living species in what appear to be essential characters. These differences consist in a combination within one genus of the form of endocarp, length of raphe, and character of chalaza which are now dispersed through several living genera.

In one genus which is closely related to *Canarium*, and for which we have reluctantly had to retain Bowerbank's name *Tricarpellites* on grounds of priority, although a more determinate name would have been better, the endocarp has the form, size, and structure of that of *Canarium;* but the seed has a raphe and chalaza such as are found in certain other genera of Burseraceae (*e.g. Bursera* and *Commiphora*), but not in *Canarium.*

In the other genus, to which we have given the name *Protocommiphora*, the characters of the endocarp would ally it with *Bursera* and *Commiphora;* but the seed has the chalaza of *Protium* and *Canarium.*

Consequently both these fossil genera indicate that a recombination of characters has occurred in the family Burseraceae during the long lapse of time since the period of the London Clay.

One other species is without doubt referable to the family but, although the fossil material is sufficient to determine its ordinal relationship, it is insufficient to determine its generic relationship, although it does show that it is not referable to either of the other two fossil genera. We have, therefore, given it the generic form-name *Bursericarpum.*

Genus TRICARPELLITES Bowerbank emend.

1840. Foss. Fruits London Clay, p. 76.

DIAGNOSIS.—Endocarps referable to Burseraceae only; syncarpous, with three one-seeded locules tangentially aligned between the rays of a three-rayed axis; sub-ovoid, triangular in transverse section; breaking (on fossilization?) into three pyrenes; germinating by sub-triangular apical dorsal valves one-third to one-half the length of the fruit; placentation axile, with two placentas, but one ripe pendulous seed. Seed half-anatropous, with hilum, raphe, and chalaza all median on the ventral face, hilum one-fifth the length of the seed from its apex, sub-triangular chalaza near the middle.

GENOTYPE.—*T. communis* Bowerbank.

Tricarpellites communis Bowerb.

PLATE X, figs. 24–37.

1840. *Tricarpellites communis* Bowerbank, p. 79, pl. xi, figs. 25–31.
1840. *Tricarpellites patens* Bowerbank, p. 80, pl. xi, figs. 32–34.
1840. *Tricarpellites crassus* Bowerbank, p. 81, pl. xi, fig. 36.
1840. *Tricarpellites aciculatus* Bowerbank, p. 83, pl. xi, figs. 39, 40.
1840. *Tricarpellites rugosus* Bowerbank, p. 83, pl. xi, figs. 41–44.
1879. *Tricarpellites communis* Bowerbank: Ettingshausen, p. 396.
1879. *Tricarpellites patens* Bowerbank: Ettingshausen, p. 396.
1879. *Tricarpellites crassus* Bowerbank: Ettingshausen, p. 396.
1879. *Tricarpellites aciculatus* Bowerbank: Ettingshausen, p. 396.
1879. *Tricarpellites rugosus* Bowerbank: Ettingshausen, p. 396.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—Decayed.

NEOTYPE.—V. 22477.

DESCRIPTION.—*Endocarp:* Sub-ovoid, roundly triangular in cross-section (Pl. X, fig. 26), bony, thick-walled, smooth externally; syncarpous, three-loculed, with two ovules (as evidenced by two placentas) but only one developed seed in each locule, the carpels throughout their length attached to a central axis which is terete below but three-rayed above, the rays penetrating between the carpels (Pl. X, figs. 25, 27, 31); placentation axile, seeds pendulous. On fossilization the endocarp tends to break into three pyrenes. Pyrene triangular in cross-section, with an oval, convex, dorsal face, and flat lateral faces meeting to form the ventral angle, which is pierced, one-fifth of its length from the apex, by the foramen for the passage of the short funicle to the immediately adjacent placenta (Pl. X, fig. 32); on the ventral faces are remains of regular hexagonal cells 0·025 mm. in diameter, which are not seen on other parts of the surface, and therefore probably belong to the axis; germination by means of sub-triangular apical dorsal valves which are from one-third to one-half as long as the carpels (Pl. X, fig. 28); endocarp formed of three coats: (1) A hard outer coat with which the germination valve is associated, varying in thickness from 0·2 to 0·8 or 0·9 mm. according to the position in the carpel, and formed of equiaxial cells from 0·025 to 0·05 mm. in diameter; (2) a coat one-cell thick of regular hexagonal cells 0·05 mm. in diameter (Pl. X, fig. 35); (3) a coat from 0·025 to 0·037 mm. thick, formed of small equiaxial cells which are either irregularly thickened or have sinuous outlines (we are uncertain which); its inner surface forms the locule-lining. Length of fruit, from 7·5 to 12·5 mm.; breadth, from 4·25 to 7·5 mm. Length of pyrene, 7·5 to 12 mm.; breadth across dorsal face, 4·25 to 4·5 mm.

Seed: Shaped like the sole of a slipper but slightly inflated, flattened on the dorsal surface beneath the germination valve (Pl. X, fig. 37); half-anatropous, with the hilum, raphe, and chalaza all median on the ventral face, the hilum being in contiguity with the placenta one-fifth the length of the seed from the apex, and the large sub-triangular chalaza, which has its apex turned to the hilum, at about the middle of the ventral face (Pl. X, fig. 36); micropyle terminal at the pointed end; testa formed apparently of at least two coats, the relationship of which is not clear; one coat is formed of spirally (?) thickened polygonal or oblong cells 0·025 mm. broad, which, on the dorsal surface, are obscured by elongate cells often only 0·009 mm. broad, the alignment of the cells on the ventral surface is concentric around the micropyle, longitudinal near the raphe and below the chalaza, radial from the margin of the chalaza and to some extent from the hilum, but becoming oblique towards the lateral margin of the seed. Length of seed, 7 mm.; breadth, 3·7 mm.; thickness, 1·1 mm.

REMARKS.—Including specimens of *Tricarpellites* which were described by Bowerbank under different specific names, but which we include in the species *T. communis*, there were originally in his possession thirty-four specimens of this species. At the time we began our study of the London Clay flora more than a dozen of these were still extant, but the greater number were in a badly decaying condition, and, as a consequence, have now very largely disintegrated. Some of these fruits, which were photographed before decay, are reproduced in Pl. X, figs. 24–27, 31, 35. We were unable to recognize any of Bowerbank's figured specimens, probably because they had already decayed beyond recognition. All the specimens were in a jar labelled by Ettingshausen "*Tricarpellites* Bowerbank." At the present time (1933) there remain, of the original collection, but a few detached pyrenes and a few fragments, either of pyrenes, seeds, or locule-casts. But six additional specimens were obtained by ourselves at Minster in 1929. Of these, four are complete endocarps and two have broken up into pyrenes. An endocarp was also found recently at Herne Bay by Mr. D. J. Jenkins.

The exocarp in *Tricarpellites communis* is usually wanting, but seems to have been preserved in a single fruit described by Bowerbank under the specific name *Tricarpellites rugosus* (1840, p. 83). He states that "the marked rugose structure of the epicarp . . . readily distinguishes it from all the preceding species." But the so-called epicarps of the other "species," as is evidenced by his own description and by the character of those specimens which have come into our hands, are not epicarps at all, but different surfaces of the coats of the endocarp, exposed by different degrees of abrasion. It follows that Bowerbank was comparing unlike parts of the fruit, and that consequently his separation of *T. rugosus* as a separate species breaks down. Similarly, in *T. aciculatus* Bowerb. (1840, p. 83) the distinctive character—" minute aciculated lines running in a longitudinal direction "—is, in all probability, due to the exposure, through abrasion, of a film of pyrites which had infiltrated between the exocarp and endocarp, and bore on its outer surface the impression of the exocarp cells. If such be the true interpretation of this species, the so-called specific character is accidental.

The entity most commonly preserved is the smooth trigonous endocarp, but perhaps, in consequence of fossilization preceded by maceration, it readily separates into three pyrenes (Pl. X, fig. 24). The same cause leads to the separation of the different coats in the endocarp, between which pyrites has commonly penetrated. Covering the locule-cast, one or another of these coats may be preserved, or it may be merely their impressions on films of pyrites or on the locule-cast itself; but according to the coat exposed so are there differences in cell-structure. When the thick outer coat of the endocarp is preserved the walls of the cells are carbonaceous, but they are usually filled with pyrites. The coat of hexagonal cells is usually represented by its impression on a film of pyrites (Pl. X, fig. 35), but some specimens show the carbonized cells themselves (Pl. X, fig. 33). The thick innermost coat of parenchyma is frequently carbonized but, when so preserved, it remains only in patches and, owing to decay, its structure is obscure.

When the endocarp and the thin layer of pyrites which forms the locule-cast are removed, either the seed itself, or its internal cast, is exposed.

In order to discover the arrangement of the carpellary and seed organs, one pyrene was broken by a median longitudinal fracture. It showed the funicle entering the locule from the axis, thence passing to the closely adjacent hilum and so, as the raphe, associated with a thickening of the testa, to the chalaza, where it terminated.

The appearance of the fruit, and many of the details of its structure, have been admirably recorded by Bowerbank, but he was mistaken in his interpretation of them. He describes the fruit the wrong way up and calls the endocarp a septicidal capsule, mistaking the separate pyrenes for septicidal valves. The inner coats of the endocarp, *i.e.* the single layer of hexagonal cells and the parenchymatous coat within it, he mistook for the seed-coats, for he describes the testa as having "a beautifully reticulated surface." The hollows left in the upper part of each carpel by the removal of germination valves he calls "excavations." The cause of these puzzled him greatly, so that after rejecting the possibility that they were produced by the attack of an insect upon the embryo, he concludes shrewdly that it "is a natural habit of the fruit, and not an accidental mutilation." The true seed, which he calls the "nucleus," he accurately describes as "faintly striated longitudinally with fine aciculated lines."

With the exception of *T. rugosus* and *T. aciculatus*, already discussed, he delimits his species by the size of the nuts and the relative length and breadth of the "valves" [pyrenes]. But such differences of proportion and size as he records are individual, not specific, as is shown by reference to living forms. Hence it follows, that the greater number of his species must be referred to *T. communis*. His species *T. curtus* and *T. gracilis* are here excluded from the genus, and are described under *Carpolithus*.

It is in no degree surprising that Bowerbank made mistakes in interpretation. That we ourselves are able to give a different interpretation is due to the fortunate chance of possessing recent material of *Canarium* which we could macerate, dissect, and study.

Affinities.—There can be no doubt that the fossils described above belong to the family Burseraceae and that they are closely related to *Canarium*, a genus with trigonous nuts formed of three carpels fused along their inner faces. Often only one locule comes to maturity, but frequently all three are equally well developed. As in the fossil, the germination valve is primarily associated with the thick outer coat of the endocarp; when this is removed, the median coat of hexagonal cells often remains intact. The structure of the endocarp, as well as that of the testa, is in agreement with the corresponding structures seen in the fossil.

The distinctive characters which separate *Tricarpellites* and *Canarium* are as follows:

(1) The raphe and chalaza. In the fossil the raphe is relatively long, although actually short, and the chalaza is a triangular area in the middle of the ventral face as in some others of the Burseraceae, but not in *Canarium*. In *Canarium* the raphe is wanting and the chalaza is an arched band of fibres. The convex apex of this arch is in juxtaposition with the hilum; its limits pass to the margins of the seed whence they continue to the base, where are the tips of the cotyledons.

(2) The shape of the valve. In the fossil this is shorter in proportion to the length of the carpel (one-third to one-half) than in *Canarium*, where it ranges from about four-fifths to two-thirds the length. In both living and fossil species the limit of the valve is shown on the seed by a curved transverse line, noted by Bowerbank. The line also marks a change in the curvature of the dorsal surface of the seed.

(3) There is also a difference between fossil and living which, in all probability, is more apparent than real; that is, the degree of cohesion of the carpels. In the fossil, the carpels, though originally connate, readily fall apart. In *Canarium* they are connate and can be separated only with the greatest difficulty. But a specimen of *C. venosum* Craib in Kew Herbarium which had apparently lain decaying on the ground for some time before it was collected, as evidenced by its condition, showed the carpels beginning to separate. This suggests that under conditions of fossilization the endocarps of *Canarium*, like those of *Tricarpellites*, might break into pyrenes.

As regards size, the fossil although smaller than most species of *Canarium*, lies within the limits of size of the genus: *C. Cumingii* Engl. measures 10 mm., and a specimen in Kew Herbarium labelled "*C. villosum* Bl." has endocarps which measure only 7 mm. in length.

In view of the distinction seen in the raphe, chalaza, and germination valve, distinctions which are probably generic, since we have been unable to find them in any living species, we do not think that the fossil should be referred to *Canarium*, although it must be closely related to it. We have therefore retained Bowerbank's generic name *Tricarpellites*. But as we have discovered the true affinities of his genus, the name must now be restricted to species of Burseraceae having the characters above described.

Canarium is a genus of forest trees, many being of gigantic size, which inhabits the coastal forests, river banks, and in some cases the hill forests of the tropics of the Old World, whilst one species occurs in the West Indies.

In consequence of the restriction in the connotation of the generic name *Tricarpellites* it follows that the practice of referring three-carpelled trigonous fruits of unknown affinity to *Tricarpellites* should henceforward cease. Twenty-four such species have been described from the Brandon Lignite of Vermont, U.S.A., by Perkins (1904). Some of these may belong to *Canarium* or an allied genus (cf. p. 185, text-fig. viii, figs. 7, 8; pl. lxxvii, figs. 45, 47), but without more knowledge of their structure than is given by the figures and descriptions, it is impossible to tell what burseraceous genus, if any, they may represent.

Tricarpellites striatus, recorded by Newberry (1896, p. 132, pl. xlvi, figs. 9–13), from the Raritan formation of New Jersey, appears to have no connection with *Tricarpellites* Bowerbank as shown by the figure. But it is only fair to state that the work was published after Newberry's death and that Dr. Hollick, who edited it, merely uses the tentative name suggested by the author without any critical investigation of its appropriateness. The name *T. striatus* Newberry is again used by Dr. Hollick for somewhat similar fossils (1906, p. 108, pl. vii, fig. 1), and later still by Professor Berry (1911, p. 223). Such specimens should provisionally be referred to *Carpolithus*.

V. 22477 Figured Pl. X, figs. 28, 29, 30. A fruit, represented by two detached pyrenes, from one of which (V. 22477*a*) the dorsal germination valve has come away.

V. 22478 Figured Pl. X, fig. 32. A detached pyrene with walls broken so that on the dorsal surface the layer of large hexagonal cells is exposed and on the ventral the locule-cast and placenta can be seen, as shown in fig. 32.

V. 22479 Figured Pl. X, figs. 33, 34. A detached locule-cast. It is figured to show the dorsal and ventral surfaces, but, since photography, has decayed and fallen in pieces.

V. 22480 Figured Pl. X, figs. 36, 37. Part of a pyrene, broken to expose the cast of the seed which has been detached and figured to show the ventral and dorsal surfaces.

V. 22481 A detached pyrene, walls broken to show the locule-cast inside and the position of the placentas. Also a second pyrene from the same fruit fractured longitudinally.

V. 22482 Twelve detached pyrenes, seeds, or fragments.

The above are from the Bowerbank Coll., Sheppey.

V. 22483 Six endocarps. Two (V. 22483*a*, *b*) have split into their component pyrenes, and one pyrene of each has subsequently been fractured transversely. *Reid & Chandler Coll.*, Minster, 1929.

The originals of Pl. X, figs. 24–27, 31, 35, have now decayed.

Genus PROTOCOMMIPHORA nov.

Diagnosis.—Endocarp ovoid, compressed dorsi-ventrally; syncarpous, with two locules (one fertile and one abortive) attached to a fibrous axis; locules two-ovuled, but only one seed maturing in the fruit; the seed pendulous from the axile placenta situated two-fifths of the length of the fruit from the apex, hilum and chalaza contiguous at two-fifths of the length of the seed from the apex, chalaza an arched band of fibres.

GENOTYPE.—*P. europaea* n. sp.

Protocommiphora europaea n. sp.

PLATE XI, figs. 1–7.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22484.

DESCRIPTION.—*Endocarp:* Ovoid, but somewhat compressed dorsi-ventrally, with attachment and style at opposite ends; syncarpous with two appressed carpels attached to a central fibrous axis which lies in a dorsi-ventrally compressed canal, not breaking into cocci, two-loculed with one mature and one abortive locule, each locule two-ovuled (Pl. XI, fig. 2), but only one seed is developed in the ripe fruit; placentation axile, seed pendulous, funicle short and passing directly into the locule, dividing to form two placentas (Pl. XI, figs. 2, 3); locule pointed-oval in outline, but slightly cordate at the base, concave dorsally, flattened ventrally, but grooved medianly on the ventral surface in the upper third of its length and roundly ridged in the lower two-thirds, the meeting place of the ridge and groove marking the position of the two placentas (cf. the locule-casts, Pl. XI, figs. 4, 5); germination (as exemplified by the behaviour of the abortive carpel, probably obscured by pyrites in the fertile locule) by large, oval, dorsal valves (Pl. XI, fig. 2); pericarp woody, formed of three coats; the outer coat, at least 0·6 or 0·8 mm. thick, formed of equiaxial cells, poorly preserved, about 0·25 mm. in diameter, with somewhat radial arrangement; middle coat (usually badly preserved) of uniform hexagonal cells, 0·05 to 0·075 mm. in diameter; inner coat about 0·1 mm. thick (usually represented by decayed carbonaceous matter), its inner surface composed of digitate interlocking cells (about 0·025 mm. in diameter including the digitations) forming the locule-lining. Length of endocarp in small specimens, 8 to 10 mm.; breadth, 5·5 to 8·25 mm.; thickness imperfect. Length of large specimen, 12·5 mm.; breadth, 8·5 mm.; thickness, 8 mm.

Seed: Ovate in outline, somewhat dorsi-ventrally compressed (Pl. XI, fig. 6; a seed lying in the locule-cast); hilum median on the ventral face about two-fifths from the apex of the seed, adjacent to the middle of the arched chalazal band of fibres (Pl. XI, figs. 3, 6, 7); testa formed of an outer coat of polygonal cells, 0·007 to 0·008 mm. in diameter, aligned approximately transversely, and an inner coat of delicate thin-walled fusiform cells (0·012 to 0·016 mm. broad) which are spirally thickened, and are longitudinally aligned except where they diverge from the arch of the chalaza. Length of a large locule-cast (virtually of the seed), 12 mm.; breadth, 8·5 mm.; thickness, 4 mm. Length of smaller locule-cast, 9 mm.; breadth, 7 mm.; thickness, 4 mm.

REMARKS.—Nineteen specimens, a few of which are perfect endocarps, and a few fragments. Two specimens are the casts of mature locules from which the carpel is lost (Pl. XI, figs. 4, 5). Two others have split irregularly along the margins so as partly to separate the fertile and abortive locules. From one of these the germination valve has fallen from the abortive locule leaving an apical depression in which lies the cast of the abortive locule. Near the apex of the cast at the level of the placenta and closely adjacent to it are two small oval depressions, symmetrically placed as regards the funicle (Pl. XI, fig. 2), which are evidently the casts of abortive seeds, lying in the pyrites which filled the locule. The seeds themselves have now either decayed or fallen. From this specimen a portion of the endocarp was removed by breaking it along the irregular crack already described (and seen in Pl. XI, fig. 2), the part removed being the cast of the abortive locule and the endocarp surrounding it. Beneath it the ventral face of the cast of the mature locule was then exposed (Pl. XI, fig. 3) with the inner coat and patches of the middle coat formed of hexagonal cells adhering to it. The internal cast of the seed is also exposed in places where the remains of the endocarp, the locule-cast, and the testa are chipped away. It shows on its surface the impression of the lining cells of the testa. On the counterpart, the external cells of the testa (impressions) are seen. Both inner and outer surfaces are somewhat confused on account of the thinness of the testa, two sets of impressions being superposed, but there are places where the two layers can be distinguished quite clearly. Both surfaces show the impression of the arched band of chalazal fibres, which is thick relatively to the testa, although the fibres actually lie on the inner side of the testa (cf. specimen figured Pl. XI, figs. 6, 7).

AFFINITIES.—The structure and form of the endocarp and seed, the placentation, and the position and form of the hilum and chalaza, are highly characteristic of Burseraceae.

The living genera, *Bursera* Linn., *Commiphora* Jacq., and *Protium* Burm. f. show the closest relationship. Of these, certain species of *Bursera* and *Commiphora* are often two-loculed and very similar in the form of the endocarp and of the abortive locule ; also in the form of the seed, the position of the placenta, hilum, and chalaza, and the character of the seed coats. Most species of *Bursera* are smaller, but *B. simaruba* Sarg. (= *gummifera* Jacq.) is about as large (length, 10 mm.) as the smaller specimens. In this species, however, the endocarp is triangular in transverse section, not flattened. *Commiphora* is more often comparable in size with the fossil ; in *C. caudata* Engl., especially, the endocarps are only a little broader in proportion to the length, but the seed differs from that of the fossil in having a large heart-shaped chalaza instead of an arched fibrous band. Similarly, in those seeds of *Bursera* that were available for study, the chalaza was an oval or heart-shaped organ. The wide-arched chalazal band is seen in both *Protium* and *Canarium*, but the endocarps of the latter are unlike in form and are invariably three-loculed, whilst in the former the chalazal band is separated from the hilum by a short raphe, which is absent from the fossil.

So far, then, as it has been possible to ascertain, the fossil differs in certain characters from all those genera of Burseraceae with which it appears to be most nearly connected. We have therefore placed it in a new genus, *Protocommiphora*, under the name *P. europaea*.

Commiphora is an entirely xerophytic genus inhabiting the tropics and sub-tropics of the Old World only, whereas *Bursera* has a habitat more in accordance with that inferred, from the presence of other genera, for the London Clay flora, being a tree of the coastal forests of tropical and sub-tropical America.

V. 22484 Holotype, figured Pl. XI, figs. 1–3. An endocarp with one fertile and one abortive locule. A germination valve is detached from the latter, the locule-cast inside being thus exposed with its two abortive seeds (fig. 2). A fracture made it possible to remove the abortive locule so as to expose the fertile locule (ventral surface) with its two placentas and its ripe seed-cast (fig. 3).

V. 22485 Figured Plate XI, figs. 6, 7. An endocarp which is fractured longitudinally so as to expose the ventral surface of the seed with the curved chalazal band, as seen on its external and internal impressions.

V. 22486 Figured Pl. XI, fig. 4. A completely detached locule-cast figured to show the ventral surface. The specimen is broken in three. On two pieces it shows the external cast of the locule and seed (ventral surface); and their counterpart represents the internal cast of the same seed (imperfect at the broad end).

V. 22487 Figured Pl. XI, fig. 5. A detached locule-cast figured to show the dorsal surface.

V. 22488 Two fruits, one imperfect, and a fragment of a third. Labelled by Ettingshausen "*Faboidea elliptica* Bowerbank," but the name is not Bowerbank's.

V. 22489 Four fruits and a number of fragments, labelled by Ettingshausen "*Hightea turbinata* Bowerbank." The specimens have no connection with Bowerbank's genus *Hightea* and do not bear even a superficial resemblance to *H. turbinata*. They are typical burseraceous fruits, some of which show the characteristic arched band of chalazal fibres.

All the above are from the Bowerbank Coll., Sheppey.

V. 22490 Nine fruits, some more or less perfect, others in various stages of abrasion. *Reid & Chandler Coll.*, Minster, 1929.

Genus BURSERICARPUM nov.

Diagnosis.—Fruits referable to the family Burseraceae, as shown by the anatomy and cell-structure of endocarps and seeds, but of which the nearer relationship cannot be determined.

Bursericarpum angulatum n. sp.

Plate XI, figs. 8–10.

Diagnosis.—Fruit ovoid, syncarpous, breaking into four (or five ?) pyrenes; placentation axile; pyrenes acutely triangular in cross-section, with placentas at the middle of the ventral angle.

Holotype.—V. 22491.

Description.—*Fruit:* Ovoid, formed of four (or five ?) pyrenes; pyrenes sharply triangular in cross-section, with the dorsal face ovate-lanceolate, and the two ventral faces flat, narrow above and broad below, and unequal in breadth, meeting at an angle rather less than 90°; placentation axile, the placentas being at the middle of the ventral angles, their position indicated by a rather broad, slightly curved, transverse band of thickening which extends on to the ventral faces, and at the centre of which is the foramen for the funicle (Pl. XI, figs. 8, 9); pericarp formed externally by polygonal or hexagonal cells 0·05 mm. in diameter (often filled with glistening pyrites), which give a close uniform surface; the main thickness of the pericarp, which is not very great (and often much worn), is formed by equiaxial cells; surface of the locule obscurely striate longitudinally (as seen on the locule-cast) but the cells are not clear; on the dorsal surface of the locule-cast is a curved line delimiting a flattened area, which may indicate the position of a germination valve (Pl. XI, fig. 10) as in other genera belonging to the family. Length of pyrene, 10 mm.; breadth across dorsal face, 6 mm.; width of ventral faces of different cocci: (i) 5·5 and 6 mm.; (ii) 5 and 5·5 mm.; (iii) 3·5 and 4·5 mm.; (iv) 4 and 4·5 mm. respectively.

Remarks.—The remains of four, or perhaps five, pyrenes belong apparently to a single fruit. One of these, if it is not a broken tip, must have been almost completely abortive, but it is now too decayed for the point to be settled. The size of the ventral angles shows that there were certainly four, and may have been five, pyrenes in the fruit, one of which was abortive, for although the four extant do not completely fill the circle there is not room for a fifth fully developed pyrene.

Affinities.—In the family Burseraceae, species of *Bursera*, *Commiphora*, and *Protium* have fruits with similar structure and placentation. But *Protium* (*Marignia*) *obtusifolium* (Lam.) March (a forest tree of Mauritius) is the only species we have seen which closely resembles the fossil in the form of its pyrenes, although these are a little larger and are only three in the fruit. This difference in number does not, however, appear to be of great importance since other genera of Burseraceae (*Boswellia*, *Canarium*, etc.) which usually have three, may sometimes have more than three carpels. Possibly reduction in the number of carpels has occurred with lapse of time, as suggested elsewhere (pp. 42, 43).

As nothing is known of the seed, we think it inadvisable to refer the fossil to *Protium*, for we have already pointed out the significance of the raphe and chalaza in the determination of genera, belonging to Burseraceae. We have therefore placed it in a new form-genus, *Bursericarpum*, under the name *B. angulatum*.

V. 22491 Holotype, figured Pl. XI, figs. 8–10. Four pyrenes belonging to one fruit, and possibly remains of a fifth. *Bowerbank Coll.*, Sheppey.

Family MELIACEAE

Genus TOONA M. Roemer

1846. Syn. Hesper., pp. 131, 139.

Toona sulcata (Bowerbank)

Plate XI, figs. 11–19; text-fig. 5.

1840. *Cupressinites sulcatus* Bowerbank, p. 61, pl. ix, fig. 22.
1840. *Cupressinites semiplotus* Bowerbank, p. 62, pl. ix, fig. 23.
1845. *Cupressites sulcatus* (Bowerbank) Unger, p. 193.
1845. *Cupressites semiplotus* (Bowerbank) Unger, p. 193.
1847. *Solenostrobus sulcatus* (Bowerbank) Endlicher, p. 8.
1847. *Solenostrobus semiplotus* (Bowerbank) Endlicher, p. 9.
1850. *Solenostrobus sulcatus* (Bowerbank): Unger, p. 343.
1850. *Solenostrobus semiplotus* (Bowerbank): Unger, p. 343.
1879. *Solenostrobus sulcatus* (Bowerbank): Ettingshausen, p. 392.
1879. *Solenostrobus semiplotus* (Bowerbank): Ettingshausen, p. 392.

Diagnosis.—Fruit ovoid, relatively broader than the fruits of comparable living species. Length, 11 to 15 mm.; diameter, 10 to 14 mm. Seed ovate in outline with one asymmetrically placed lateral wing directed towards the apex of the fruit.

Holotype.—No longer extant.

Neotype.—V. 22492.

Description.—*Fruit:* Ovoid, shortly stipitate (Pl. XI, fig. 11; also Bowerbank, 1840, pl. ix, fig. 22), although the stalk is easily detached; syncarpous, five-loculed, with about ten winged seeds in each locule, having the wings directed upwards and overlapping one another like the tiles of a roof, closely appressed, and lying obliquely in the locules in two longitudinal rows, the seeds of one row alternating with those of another (Pl. XI, figs. 16, 17; also text-fig. 5*a*); placentation axile, the seeds being suspended laterally from the rays of a thick five-rayed axis,

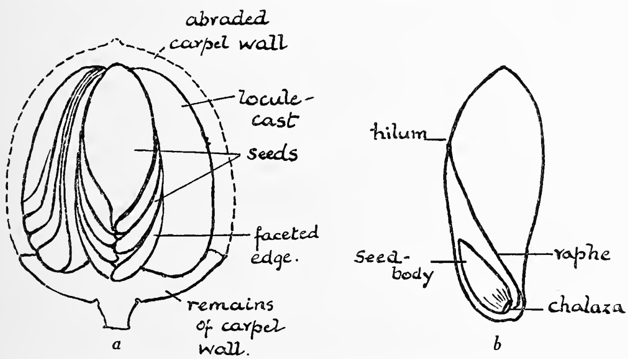


Fig. 5.—*Toona sulcata.* *a*, cast of fruit showing the arrangement of the seeds in the locules. Diagrammatic. *b*, seed (diagrammatic) to show structure.

which has a core of parenchyma and a sheath of longitudinal fibres, the rays passing into and connecting with the septa (Pl. XI, figs. 13, 15); dehiscing septicidally at the apex but also tending to gape loculicidally as evidenced by a slight incurve of the wall to form a shallow longitudinal groove (Pl. XI, fig. 12) along the middle of which is sometimes a slight ridge of pyrites; pericarp thick with a very rugose outer surface; outer coat formed of fibres, many of which are tortuous but have a general radial direction; middle coat of fibres which are transverse throughout the coat, including the septa; the locule is lined by smooth fine fibres which diverge from the base to take a longitudinal direction. Length of fruit, 11 to 15 mm.; diameter, 10 to 14 mm.

Seed: Ovate in outline, compressed, winged laterally; the seed-body is ovate-lanceolate in outline; it has a faceted margin (broad below, narrowing above), which is not covered by other seeds; the lateral faces, which are covered by other seeds, are either hollowed or flattened; the wing is thin, flat, stiffened along its shorter free margin by a thin strand of fibres which branches from the raphe, arising laterally but asymmetrically from the seed-body, so that on the proximal margin it occupies one-third of the complete length of the seed, and on the distal margin the whole length (text-fig. 5*b*), lower seeds longer than the upper; anatropous, with the hilum terminal at the narrow upper end of the seed-body (as it lies in the fruit) at its junction with the wing, chalaza a large oval scar at the opposite rounded end of the seed-body, and raphe lateral along the junction of the seed-body and wing (text-fig. 5*b*); micropyle adjacent to hilum; testa formed of more than one layer of inflated, irregular, somewhat elongate cells which vary in their size and alignment in different parts of the seed; over the surface of the wing the cells are long, irregularly aligned, and tortuous, although the general alignment is longitudinal; along the short margin (that carrying the fibre) they are close, fine, and elongate, producing fine striations; towards the interior of the testa the cells over the wing become longer and more contorted, whereas over the seed-body they are longitudinally aligned; on the faceted margin they measure superficially 0·025 mm. by 0·05 mm.; tegmen formed of thin-walled oblong cells aligned in longitudinal rows which converge towards the micropyle and chalaza. Length of seed, 6 to 11 mm.; breadth, about 2·5 mm.

REMARKS.—Twelve specimens. One small fruit has the pericarp almost intact; the valves have begun to gape at the apex, and at the base is the deep scar of attachment, where the thick stalk has come away. Another fruit also has the pericarp well preserved; later it was fractured. All the other specimens are internal casts of the fruit. These reproduce exactly the impressions left by the closely packed seeds upon the locule walls, and within their substance the remains of the seeds themselves, or their casts, are sometimes found. The carbonaceous matter of the seeds has mostly decayed, but the impressions of the cells which formed it remain on the pyrites which has penetrated between the seeds themselves and between the seeds and the pericarp. The fruit mentioned above was fractured in order to discover whether those fruits with the pericarp remaining were the same as those from which it had been worn away. The fracture proved that they were.

In Bowerbank (1840, pl. ix, fig. 22) a specimen is figured as *Cupressinites sulcatus* which undoubtedly belongs to the species above described. Although the specimen has now disappeared, its shape and size, and Sowerby's delicate figure which shows the seeds overlapping at the apex, leave no doubt as to its identity. This is still further proved by Bowerbank's own statement (p. 62): "Each segment is composed of a series of layers of vegetable tissue, which project beyond each other in succession, from the lower portion of the fracture [the portion from which the pericarp has been removed] to the apex of the segment." Evidently he saw, what the figure shows, the overlapping seeds. The fig. 22 shows a short stalk (cf. Pl. XI, fig. 11) and two lateral appendages which Bowerbank states may be either bracts or accidental accretions. They are probably the latter.

Another specimen figured and described by Bowerbank as *Cupressinites semiplotus* also probably belongs to this species (1840, p. 62, pl. ix, fig. 23). It is of similar form and size to, and closely resembles, a fruit figured by ourselves (Pl. XI, fig. 14), and is possibly the identical specimen, although the details are insufficient to prove this.

Affinities.—The peculiar arrangement and form of the winged seeds leaves no doubt at all that they must be referred to the family Meliaceae. Similar five-loculed dehiscent fruits with overlapping, pendulous, anatropous, winged seeds attached to a large angular axis occur in this family, the most comparable fruits being found in *Swietenia* Jacq., *Pseudocedrela* Harms, *Cedrela* P. Brown, and *Toona* Roem. In these the axis is either pentangular or five-rayed, the faces between the angles or rays being flat or concave. The fruits of *Swietenia* and *Pseudocedrela* can at once be discarded both on account of the enormously greater size of fruit and seeds, and because the seeds are attached medianly between the angles or rays, at the apex of the axis, by the extreme tip of the wing. In *Cedrela*, although some species have fruits considerably larger, others are comparable in size with the fossil. Nevertheless the seeds differ, for the wing is directed towards the base of the fruit, not, as in the fossil, towards the apex. *Toona* has fruits of comparable size and form and the seeds are usually attached to the angle or rays of the axis at one-third of the length from the apex. The genus is divided into two sections: (1) In the section Dipteron of Harms the seeds have two wings, one arising from the raphe directed to the apex of the fruit, the other arising from the opposite margin of the seed-body directed towards the base. To this section belong *T. ciliata* Roem. (*Cedrela Toona* Roxb.) from India, the Malay Islands, and Australia, *T. microcarpa* (C. DC.) from western Hupeh, *T. inodora* (Hassk.) from the Malay Islands, *T. febrifuga* (Forst.) from India, Penang, and Java, and *T. calanta* Merr. & Rolfe from the Philippines. (2) In the section Monopteron of Harms the seeds have one wing only directed towards the apex of the fruit. These fruits and the one-winged type of seed are so closely comparable with the fossil that we do not hesitate to refer it to the genus *Toona*. The species which most resemble it are *T. sinensis* (A. Juss.) and *T. serrata* (Royle), but they differ in their rather larger size and more elongate form. Typical fruits of *T. sinensis* measure 22 to 37 mm. in length, and 12 to 16 mm. in breadth (measured at the middle of a dehisced fruit), a typical seed measures 13 mm. in length, and 5 mm. in breadth. It is a large tree found in Yunnan both in the plain of Mengtzes and up to a height of 4,000 or 5,000 feet, also in western Hupeh, Foochow, and Kwangtung. *T. serrata* has fruits and seeds of the same size as those of *T. sinensis*. It occurs in India, growing in Manipur at 4,000 to 6,000 feet; the Punjab at 6,500 to 7,000 feet, and Burma at 3,500 feet; also in Java, at 5,200 feet, and Sumatra. *Toona* is a genus confined to the Old World, and was first described by Roemer in 1846.

In the genus *Cupressinites*, by us restricted to a single species, Bowerbank also included species now known to belong to genera of widely different affinities (see p. 96). The meliaceous fruit here described, which was originally named *Cupressinites sulcatus* by Bowerbank in 1840, may, therefore, be transferred to the genus *Toona* under the name *T. sulcata*. This is another case of a genus which was found as a fossil in Britain before it was recognized as a living one in the East (cf. *Petrophiloides*, p. 133).

V. 22492 Neotype, figured Pl. XI, figs. 12, 13. A fruit with carpel walls preserved, fractured longitudinally to show axis and septa (somewhat puckered and distorted).

V. 22493 Figured Pl. XI, fig. 15. A fruit, internal cast showing the overlapping seeds (seen as casts) in the locules.

V. 22494 Figured Pl. XI, figs. 16, 17. A fruit, internal cast of locules with remains of carpel wall at base. The impressions made by the overlapping seeds on the locule-lining are clearly reproduced on the cast.

V. 22495 Figured Pl. XI, fig. 18. A fruit, with remains of carpel wall. The specimen is partly dissected to show the impressions of the seeds. Two of the seeds adhering to a pyrites film are figured.

V. 22496 Figured Pl. XI, fig. 19. A fruit, internal cast with remains of carpel wall. The impressions due to the seeds are reproduced on the locule-casts as in V. 22494. The specimen is partly dissected to show the seeds lying within the locule-cast. The testa of one seed has been removed and the longitudinal striate tegmen with terminal chalaza is exposed.

V. 22497 Figured Pl. XI, fig. 11. Fruit with remains of stalk (cf. "*Cupressinites sulcatus*" of Bowerbank). The fruit has been fractured longitudinally and the seeds and septa exposed.

V. 22498 Figured Pl. XI, fig. 14. Fruit with carpel wall preserved (cf. "*Cupressinites semiplotus*" of Bowerbank, perhaps the original of his pl. ix, fig. 23).

V. 22499 Four fruits. Three are locule-casts with little or no carpel wall preserved. The fourth is a fruit longitudinally compressed, with carpel wall preserved.

V. 22500 A fruit with carpel wall, abraded. Now fractured to confirm identity.

All are from the Bowerbank Coll., Sheppey.

Genus MELICARYA nov.

Diagnosis.—Fruit syncarpous, nine- or ten-loculed, the locules arranged radially around a thick axis ; placentation axile, the placenta about half-way along the axis ; seeds attached at the middle of the ventral margins, solitary in the locule. Seeds half-anatropous, hilum median on the ventral margin, chalaza terminal at the end turned to the base of the fruit, raphe ventral ; micropyle at the end opposite to the chalaza.

Genotype.—*M. variabilis* n. sp.

Melicarya variabilis n. sp.

Plate XI, figs. 20–24.

Diagnosis.—That of the genus.

Holotype.—V. 22501.

Description.—*Fruit:* Sub-globular or ovoid; syncarpous, nine- or ten-carpelled, nine- or ten-loculed ; carpels arranged radially around an elongate-ovoid axis (truncate at both ends ?) which extends from base to apex, the diameter of the base being rather greater than that of the apex, at the top of each carpel is a small hole which leads to its ventral wall and may be associated with the fibres of the axis, the holes together form an apical ring ; the axis (Pl. XI, fig. 24) is formed of longitudinal fibres, embedded in parenchyma (in most specimens it has decayed, its place being taken by pyrites, Pl. XI, figs. 22, 23) ; locules evenly spaced, radially arranged around the axis, sausage-shaped, but tapering at the lower end, there is a marked tendency for some to be abortive (Pl. XI, figs. 20, 21) ; placentation axile, the placentae being at the middle of the axis where it is thickest and at the middle of the locule, and the seeds suspended by the middle points of their ventral margins

(Pl. XI, fig. 22); dehiscence loculicidal, the carpels also probably breaking into pyrenes as evidenced by specimen V. 22505; pericarp formed of an outer coat of woody parenchyma which is thin around the middle of the locules, but very thick around their tapering ends; the inner coat is formed of several layers of elongate fibrous cells, those of successive layers being differently aligned; the layer which lines the locule consists of elongate cells obliquely or transversely aligned except at the extremities where the alignment is concentric (according as the lining layer alone shows, or its cells are confused by the impressions of other layers, so does the surface appear striate or criss-cross). Length of fruit, 11 mm.; diameter, 7 mm.; length of locule, 8 mm.; diameter, 2·8 mm.

Seed: The fully developed seed is sausage-shaped and fills the locule; half-anatropous, with hilum median on the ventral margin, raphe ventral, chalaza terminal at the end of the seed turned towards the base of the fruit; micropyle terminal at the end opposed to the chalaza, and turned outwards (as indicated by the curvature of the apex of the locule); testa with an outer coat finely striate longitudinally, the striae being formed by the thickened lateral walls of small cells aligned in longitudinal rows; an inner coat formed of small polygonal cells is obscure and badly preserved, and the cells could not be measured. Length and diameter of the seed approximately those of the locule.

REMARKS.—Four fruits and two detached pyrenes belonging to a fifth fruit. The holotype is so worn that the dorsal surfaces of the nine locule-casts are exposed, and they are seen grouped around the central mass of pyrites which occupies the place of the axis (as indicated by another specimen). Between the locule-casts some of the pericarp is preserved (Pl. XI, figs. 20–22). The specimen was fractured longitudinally, the plane of fracture passing through the middle of one small locule, the middle of the axile mass of pyrites, and the interlocular pericarp on the opposite side (Pl. XI, fig. 22). The fracture showed the funicle passing into the locule, and thence to the hilum; this fact together with the ventral raphe and the basal chalaza, indicate quite definitely the manner of placentation and suspension of the seed, and its half-anatropous character (Pl. XI, fig. 22). A second fruit, collected by ourselves, is rather irregularly pyritized and, in consequence, on fracturing, it shattered into many pieces. Nevertheless it is important because it shows the axis, which is preserved in no other specimen (Pl. XI, fig. 24). The rare preservation of the axis in this species may be compared with a similar phenomenon in *Hightea* (p. 442). In the third fruit the pericarp is preserved. Consequently it appeared outwardly as a smooth ovoid body devoid of any significant structure. But when fractured longitudinally and transversely it showed the structure of the other fruits, and ten, instead of nine, locules, several being abortive. The fourth fruit is distorted (in life ?), and unevenly abraded, so that the asymmetric axis is partially exposed giving it a superficial resemblance to a palm-seed. The fifth fruit is imperfect, being represented by two pyrenes; these show loculicidal dehiscence, the locule, placentae, and locule-casts being exposed.

AFFINITIES.—There is only one family, so far as we are aware, which embraces all the characters of this species—the number of locules, loculicidal dehiscence, thick columella, solitary, pendulous anatropous seeds with ventral raphe—that is the Meliaceae ; but we have been unable to discover any genus in this family which closely compares with the fossil. This is not surprising, as the fruits of many genera and species are unknown ; and we have only been able to make microscopic comparison with a few species. Among others we examined two species of *Melia* Linn., but, while these afford no very valuable subjects for comparison, they show that the lining of the locule is similar to that of the fossil. Noticeable differences are seen in the smaller axis and lesser number of locules in *Melia ;* also in *Melia* the placentation is from the apex of the axis, not from the middle as in the fossil ; and the seeds are anatropous, not half-anatropous like the fossil seeds.

The genus *Quivisia* Comm. ex Juss. is also similar ; it has a loculicidal capsule with a stout axis (thickest about the middle of the locule) from which the seeds are suspended, but the locules are only five in number ; the anatropous seeds are paired in each locule, and the hilum is terminal not median.

We have given the species the name *Melicarya variabilis* on account of its suggested affinities, and of the variability of its form and the number and development of its locules.

There is no relation between *Melicarya* and Menzel's *Meliaceaecarpum* from the Miocene (1913, p. 39).

V. 22501 Holotype, figured Pl. XI, figs. 20–22. A fruit with carpel wall abraded so as to expose the locule-casts. The decayed columella is represented by pyrites. The specimen is fractured longitudinally and shows the placentation and the half-anatropous seed. *Bowerbank Coll.*, Sheppey.
V. 22502 Figured Pl. XI, fig. 24. A fruit irregularly pyritized and hence with irregular fracture. The only specimen in which the organic structure of the columella is preserved. *Reid & Chandler Coll.*, Minster, 1929.
V. 22503 Figured Pl. XI, fig. 23. A fruit with the carpel walls more or less preserved. Fractured both longitudinally and transversely. *Reid & Chandler Coll.*, Minster, 1929.
V. 22504 A distorted and irregularly abraded fruit. *Reid & Chandler Coll.*, Minster, 1929.
V. 22505 Two pyrenes from one fruit, which show loculicidal dehiscence. *Bowerbank Coll.*, Sheppey.

Family MELIACEAE ?

Genus ?

Plate XI, figs. 25–27.

Description.—*Fruit:* Ovoid ; syncarpous, but number of locules uncertain, probably four or five, septa very thin, no axis seen ; pericarp woody, formed of elongate cells with irregular alignment producing a tortuous effect as seen in transverse sections of the fruit ; surface of locule longitudinally striate.

Seeds: Apparently winged, the wings lying in the upper part of the fruit ; they also appear to be placed at different heights one above the other, but we were unable to detect the plan on which they were arranged ; wing flat, seed-body inflated ; chalaza basal (as evidenced by a circular scar, from which the cells radiate, on the flat surface of the seed near the end turned to the base of the fruit) ; testa smooth externally and formed by an outer coat of several thicknesses of small polygonal cells; and a middle coat formed by several layers of sharply angular polygonal cells 0·016 to 0·025 mm. long; the lining of the testa being formed by equiaxial cells 0·012 mm. in diameter. Some seeds may have been abortive as one is much larger than the others.

REMARKS.—A fragment of a fruit containing seeds. It had already been broken both longitudinally and transversely, and was in several pieces, before it came into our hands. The sections thus formed are very confusing and difficult to understand. It has been impossible to discover the mode of attachment of the seeds, but they were evidently closely packed with wings directed upwards. Partly the want of evidence is due to the fact that the top of the fruit is lost. Again, in consequence of the incomplete state of the specimen we cannot tell the number of locules. The form, so far as that is known, and the arrangement of the winged seeds suggest affinity with Meliaceae, but the evidence is too incomplete to speak with confidence.

V. 22506 Figured Pl. XI, figs. 25–27. Part of a fruit with seeds. *Bowerbank Coll.*, Sheppey.

Family EUPHORBIACEAE

The family Euphorbiaceae is very clearly characterized by the features both of the fruit and seed, which are remarkably uniform and constant. This makes it easy to detect both fossil fruits and seeds which belong to it. At the same time the very uniformity, coupled with the enormous size of the family, makes it extraordinarily difficult, and most often impossible, to discover the generic relationship.

The following are ordinal characters when found in combination:—(1) Of the fruit: Septicidal and loculicidal dehiscence in the same fruit, the septicidal dehiscence being produced by a peculiar structure of the septa which causes the trigonous cocci to separate resiliently; an oblique downward alignment of the fibres forming the endocarp, from the median line of its dorsal surface to the edges of the septa; axile placentation; locules (usually three) one- or two-seeded. (2) Of the seed: Obovoid form, mostly (not universally) truncate or obliquely faceted at the hilar end, the truncation showing a pair of depressions separated by a short conspicuous, or obscure, median ridge (the arrangement in the living seeds being usually associated with an aril); anatropous seeds with the hilum median near the narrow end, chalaza terminal at the opposite rounded end, and raphe median on the ventral face; testa with the hard outer coat formed of cells which are always polygonal and close-set in surface view, and in radial sections of the seed show a columnar arrangement, the columns being either curved or inclined, in parts.

Though difficult to trace generic relationship among the fossil seeds of Euphorbiaceae, it is comparatively easy to distinguish between species. The study of living seeds shows that species are extremely constant in their characters, and that small differences in certain features imply specific distinctions, even though the generic relationship may be unknown. The characters which are useful for specific determination are the following: The size of the seed; its form, especially the form and faceting of the hilar end; the thickness of the columnar coat of the testa; the size of the cells which form it; and the size of the cells of the inner coat.

Among the fossil seeds many have had the actual testa completely, or almost completely, removed by abrasion; but even in such specimens the impressions of the cells forming the columnar coat of the testa usually remain, and can be measured on the surface of the internal seed-cast. Sometimes also when the inner coat has been in close contact with the outer columnar coat, or partially fused with it, the cells of both coats can be seen superposed on the surface of the cast.

On account of the well-marked characteristics of the family outlined above, and of the difficulty of recognizing individual genera, we have instituted two form-genera for fossil material—*Euphorbiotheca* for fruits, and *Euphorbiospermum* for seeds which can be referred to the family, but of which the nearer affinities are not known. We are unable to adopt Knowlton's name *Euphorbocarpum* (1917, p. 328), as it was not used as a form-name but was restricted to one definite species (very doubtfully Euphorbiaceae judging by the illustration), and is quite inapplicable to Euphorbiaceae as a whole.

Genus EUPHORBIOTHECA nov.

Diagnosis.—Dehiscent fruits referable to the family Euphorbiaceae, the nearer affinities of which are not known. Hence the different species need not be closely related.

Euphorbiotheca sheppeyensis n. sp.

Plate XII, figs. 1–5.

1840. *Wetherellia variabilis* Bowerbank (pars), p. 84, pl. xii, figs. 6, 7.

Diagnosis.—Fruit a sub-globose three-loculed, three-seeded capsule; placentae at one-third the length from the apex; length, 13·5 mm.; greatest diameter, 17 mm.; least diameter, 12 mm. Seed obovoid, obliquely faceted, the facet making an obtuse angle with the ventral face; cells of columnar coat of testa, 0·02 mm. in diameter; cells of inner coat, 0·05 mm. in diameter. Length, 7 mm.; breadth, 5·5 mm.

Holotype.—V. 22507.

Description.—*Fruit* (now distorted by lateral pressure): Sub-globose, sub-conical above and flattened below, with six lateral grooves, three over the septa, three over the median planes of the carpels; the septal grooves, near the apex, widen at one point to permit the passage to the exterior of fibres from the axis (as in many Euphorbiaceae); three-loculed, three-seeded, the seeds pendulous from axile placentas at the apex of the locules, *i.e.* from a point about one-third the length of the fruit from the apex; dehiscence both septicidal and loculicidal (but in the fossil the septicidal planes of weakness are cemented by infiltrated pyrites); pericarp with an outer coat of coarse fibres directed obliquely upward from the septal grooves to the loculicidal grooves; a middle coat of fine fibres radially directed, and an inner coat of coarser fibres lying approximately longitudinally, but slightly obliquely. Length of fruit, 13·5 mm. ; greatest diameter, 17 mm. ; least diameter, 12 mm. Length of locule, 7 mm. ; radial diameter, 6 mm.

Seed (longitudinally fractured by fracture of the fruit) : Obovoid, obliquely faceted at the narrow end, the facet making an obtuse angle with the ventral face ; anatropous, the hilum being at the narrow faceted end, and the chalaza at the opposite rounded end ; testa (now decayed, represented by the impressions of the cells of both coats on the seed-cast) formed of an outer (columnar) coat of cells 0·02 mm. in diameter, and an inner coat of polygonal cells 0·05 mm. in diameter. Length of seed, 7 mm. ; greatest breadth, 5·5 mm.

REMARKS.—One perfect fruit which split loculicidally, but somewhat irregularly, on cleaning and drying. The seeds, which are broken longitudinally, are partially cemented to the pyrites which is intercalated between them and the carpels. Consequently their surface characters are not completely shown. Bowerbank (1840, pl. xii, figs. 6, 7) figures (in two positions, natural size, as *Wetherellia variabilis*) a fruit which differs only in the slightest degree from the one we have just described. The length both of the fossil and of the figure is 13·5 mm., and the greatest diameter 17 mm. The only discernible difference between the two is a slightly increased curvature in the septal groove in Bowerbank's figures (the median groove in the figures), and some very slight differences in outline. It can hardly be doubted that we have in the specimen we are describing the original of Sowerby's engravings. If so, two entirely different fruits have been associated by Bowerbank under the name *Wetherellia variabilis*, which must, of course, be retained for the typical fruits depicted in the greater number of the figures, and clearly described in the text. Hence it is necessary to give the fruit we have just described a new name.

AFFINITIES.—Every detail of structure both of fruit and seed indicate a relationship with Euphorbiaceae, but in view of the difficulty of relating fossil genera to living, referred to above (p. 283), more especially when one fruit only is known, we have referred the fruit under discussion to the form-genus *Euphorbiotheca*.

We have compared the seeds with all the isolated seeds found in the London Clay, but none of them would seem to fit the locules of this fruit, and none shows the same size of cells in the two coats of the testa combined, although they may show one or another of them. There is, therefore, good reason for thinking that none of the isolated seeds to be described belongs to this species.

V. 22507 Holotype, figured Pl. XII, figs. 1–5. A three-loculed fruit with seeds, almost certainly the type of Bowerbank's pl. xii, figs. 6, 7 (1840). It was in a jar with other fruits labelled by Ettingshausen "*Faboidea* Bowerb.", to which genus it bears no resemblance. *Bowerbank Coll.*, Sheppey.

Euphorbiotheca obovata n. sp.

PLATE XII, figs. 6, 7.

DIAGNOSIS.—Fruit (distorted by lateral compression) obovoid, five-loculed; seeds solitary in the locules, pendulous. Length, 19 mm. ; shortest diameter, 6 mm. ; longest, 11·5 mm. Seeds obovate, compressed dorsi-ventrally, probably arillate ; columnar coat of testa formed of cells 0·016 mm. in diameter, inner coat of cells 0·05 mm. in diameter. Length, 5·5 mm. ; diameter, approximately 3·5 mm.

Holotype.—V. 22508.

Description.—*Fruit:* Sub-obovoid, five-angled, five-loculed, the locules tangentially compressed, inflated in the upper half where are the seeds, but with nearly contiguous walls below, seeds solitary in the locules, pendulous; dehiscence loculicidal; exocarp formed of parenchyma (some cells measuring 0·05 mm. in diameter, others considerably less), which is much developed between the locules so as to fill in the deep re-entrant angles of the endocarp and give more rounded contours to the fruit, endocarp thick, formed of oblique fibres which also line the locule, and with strong strands of longitudinal fibres along the margins of dehiscence. Length, 19 mm.; shortest diameter, 6 mm.; longest, 11·5 mm. (unequal because of lateral distortion).

Seed: Obovate, slightly compressed dorsi-ventrally at the rounded end and much compressed at the narrow end; anatropous, with the hilum at the narrow end, where a pair of small ventral depressions separated by a short ridge probably indicate an aril (now decayed), and the chalaza at the broad rounded end, where it is marked externally by a small conical mucro and internally by a corresponding funnel-shaped depression surrounded by a large circular area sharply differentiated from the rest of the surface, a thickening of the testa over the chalaza being now represented by a decaying mass of carbonaceous matter; testa formed of (1) an outer coat of regular polygonal cells 0·025 mm. in diameter, its thickness uncertain but probably not more than one or two cells thick; (2) a thicker coat (0·075 mm. thick) with sharply defined surfaces formed of cells varying in diameter in different parts but commonly 0·016 mm., which are polygonal in surface view and have a columnar arrangement (curved in parts) in radial sections of the seed; (3) an inner coat of thin-walled irregular angular cells, about 0·05 mm. in diameter over the middle of the seed where they are largest. Length, 5·5 mm.; breadth, 3·5 mm. (somewhat increased by distortion).

Remarks.—One fruit, somewhat worn and distorted. It shows clearly the five-angled form, although three of the faces are so abraded that the seeds are exposed (Pl. XII, figs. 6, 7). On two faces these are represented by external moulds (Pl. XII, fig. 6, right; fig. 7, left; these two figures do not represent counterparts, but opposite faces of the worn fruit); on the third face is an external mould with the seed-cast lying within it (Pl. XII, fig. 7, right) whilst between the mould and cast are the remains of the outer coats of the testa, and where these have been worn away, the remains of the inner coat. A section across the fruit below the level of the seeds shows that one locule certainly was abortive, and that a second is but doubtfully fertile.

Affinities.—Five-loculed, loculicidal capsules with a single anatropous seed in each locule, the seeds having large chalazal scars, suggest comparison with Tiliaceae and Sterculiaceae. And it was with these families that we first sought for relationship. But an accidental fracture of the specimen showed the curved columnar coat of the seed, a feature unknown in the two families named, but occurring in Euphorbiaceae as one of its most characteristic features. The relationship to this family is further supported by the structure of the fruit and by the pair of hilar depressions on the seed. Five-loculed Euphorbiaceae are relatively scarce, although they occur in a few genera. The fossil may belong to one of these genera, but the evidence is wanting because we have not had the opportunity to pursue the question to its conclusion. Without evidence it is not safe to decide on such a relationship, for experience with other families shows that there has been in several a reduction in the number of locules with lapse of time. Consequently it is possible that living three-loculed genera may formerly have included species with more than three locules. We have therefore referred the fossil to the new form-genus *Euphorbiotheca* under the name *E. obovata*.

V. 22508 Holotype, figured Pl. XII, figs. 6, 7. A five-loculed fruit. *Bowerbank Coll.*, Sheppey.

Euphorbiotheca minor n. sp.

PLATE XII, figs. 8–10.

DIAGNOSIS.—Fruit sub-globose, roundly three-lobed, obscurely six-lobed, slightly depressed at base and apex; three-loculed, the locules each with two seeds as inferred from the six-lobed form. Length, 4·6 mm.; diameter, 6·3 mm.

HOLOTYPE.—V. 22509.

DESCRIPTION.—*Fruit:* A capsule, sub-globose, with three principal lobes which are subdivided along median planes to form six obscure lobes, somewhat depressed at the base and apex; three-loculed with two seeds in each locule as inferred from the six-lobed form; dehiscence septicidal into cocci, then loculicidal; pericarp (as preserved) showing, superficially, fibres which diverge obliquely downwards from the plane of loculicidal dehiscence to the septal planes, and in section a thickness of cells (fibres ?) with columnar arrangement, the columns being oblique; the locule lined by rather coarse elongate cells which diverge obliquely from the placentas near the top of the locule. On the septa are grooves (or fissures ?) which also arise from near the placentas, and are directed obliquely downwards (Pl. XII, fig. 10). Length, 4·6 mm.; diameter, 6·3 mm. Seeds too undeveloped for description.

V. 22509 Holotype, figured Pl. XII, figs. 8–10. A fruit, fractured to show locules and septa. *Bowerbank Coll.*, Sheppey.

Euphorbiotheca obscura n. sp.

PLATE XII, figs. 11–16.

DIAGNOSIS.—Fruit ovoid, with three two-seeded locules. Length, 6 mm.; diameter, 4·5 mm. Length of seed, 3·75 mm.; dorsi-ventral diameter, 2·5 mm.

HOLOTYPE.—V. 22510.

DESCRIPTION.—*Fruit:* An ovoid capsule, three-loculed, with two pendulous seeds in each locule, and a fibrous axis two-thirds as long as the fruit; dehiscence septicidal and almost certainly loculicidal also (as indicated by dorsal sutures); pericarp thick dorsally, thin between the locules; (as preserved) formed, over the dorsal surface, of an outer coat of fibres, a few cells thick, which are directed obliquely downwards from the loculicidal planes, where the two sets meet at sharp angles, (Pl. XII, fig. 14) to the septa, the dorsal surfaces being correspondingly striate; over the septa, the fibres become obliquely or transversely aligned (according to the position on the carpel) towards the base of the axis ; within this coat is another formed of fibres radially aligned on the dorsal surface where the coat is thick, but becoming variously aligned over the septa where it is thin and where they form a few superposed layers which produce a criss-cross effect ; the innermost layers which are subhorizontal gradually die out and cease towards the axis ; the locule shows a smooth, polished, obliquely striate surface (only seen in a few small patches) formed of large elongate cells (Pl. XII, fig. 13) ; on the surface of each septum one, or sometimes two, vascular bundles run obliquely upwards from the top of the axis to the outside of the carpel (Pl. XII, figs. 12, 15), and there is a large gash in each septum which runs obliquely downwards from the top of the axis (Pl. XII, fig. 15). Length of fruit, 6 mm. ; diameter, 4·5 mm. Length of a detached carpel from a second specimen, 7 mm. ; breadth across dorsal face, 5 mm. ; radial breadth of septa, 2·5 mm. and 3·5 mm., respectively.

Seed: Known only from a poor impression of the exterior of a developed seed within a locule-cast (Pl. XII, fig. 16) and a perfect, but abortive seed in the same locule. Both show the testa to have been formed of large inflated polygonal cells, perhaps with slightly sinuous outlines due to irregular thickening, or to shrinkage. Length, approximately 3·75 mm. ; diameter, approximately 2·5 mm.

REMARKS.—A complete fruit which had fallen into three cocci (Pl. XII, figs. 11–13), a fourth larger coccus (Pl. XII, figs. 14, 15), and half of a fifth coccus which appears to have split loculicidally, after which the pericarp became worn or broken (Pl. XII, fig. 16). The half coccus shows the impression of the developed seed and the internal cast of the abortive seed with minute fragments of the testa still adhering to it. The developed seed appears to have occupied the whole locule, the abortive seed being pushed on one side. One of the three carpels forming the perfect fruit was sectioned and showed the structure of the pericarp. This was better seen when later the large detached coccus was found.

AFFINITIES.—There can be no hesitation in assigning this species to the Euphorbiaceae, since similar structure of fruit and seed occurs in many genera. The narrow form of the fruit is, however, unusual among fruits with two seeds in each locule, although it is common among fruits with one seed. We have referred the species to the form-genus *Euphorbiotheca* as *E. obscura*.

V. 22510 Holotype, figured Pl. XII, figs. 11–13. A three-carpelled fruit.
V. 22511 Figured Pl. XII, figs. 14, 15. A detached carpel, showing the oblique fibres on the outside of the carpel, and the oblique slit in the septum within.
V. 22512 Figured Pl. XII, fig. 16. Half a detached coccus, fractured longitudinally, but somewhat irregularly, through the locule, showing the external cast of the seed on the pyrites which fills the locule cavity.

All are from the Bowerbank Coll., Sheppey.

Euphorbiotheca (?) *pentalocularis* n. sp.

PLATE XII, figs. 17–19.

DIAGNOSIS.—Fruit ovoid, syncarpous, five-carpelled, breaking septicidally into five two-seeded pyrenes which subsequently dehisce loculicidally ; on the septa from four to six flat bundles of fibres diverge from the central axis to the margin of the pyrenes, the largest arising from the placentae which lie at the middle of the axis. Length of coccus, 8·5 mm.

HOLOTYPE.—V. 22513.

DESCRIPTION.—*Fruit:* Ovoid, syncarpous, breaking initially into five two-seeded pyrenes which are triangular in cross-section, have straight ventral margins where they abut upon the central axis, and convex dorsal margins; later, they split loculicidally (as evidenced by a median longitudinal ridge of pyrites on the dorsal face which has been intercalated into the gaping loculicidal split); pericarp (as preserved) thick over the dorsal face where it is formed of radially directed cells (or fibres ?), and thin over the septa where it is formed of parenchyma; on the surface of the lateral faces (septa) are from four to six large fibro-vascular bundles which diverge from the axis (the longest from the middle, where are the placentae, others from below the middle and occasionally from above) and, after branching once or not at all, reach the dorsal margin and pass on to the dorsal surface beneath the outer layers of the pericarp, where they form a network which is also connected with a stout bundle of fibres lying on the line of loculicidal dehiscence. Length of pyrene, 8·5 mm.; breadth of dorsal face, 4 mm.; breadth of lateral faces (septa), 3·25 mm.

REMARKS.—One fruit, which had broken into pyrenes before it came into our hands, the pyrenes showing very beautifully the divergent fibres on the septa. One pyrene appeared to indicate the presence of two seeds attached to the median placenta, one in the upper part the other in the lower part of the carpel. This carpel was therefore fractured and the presence of two seeds established. Both were, however, undeveloped and too decayed to show the arrangement of the seminal organs, or the structure of the testa, which appeared to be rough.

AFFINITIES.—We were at first completely at a loss to discover the affinity of this species, but when studying the Euphorbiaceae found that certain genera showed similar systems of fibro-vascular bundles diverging from the top of the axis over the surface of the septa. Nevertheless this evidence is not sufficient to refer the fossil species definitely to the Euphorbiaceae, for we have found a somewhat similar structure in *Buettneria* (Sterculiaceae), in which fruit it may also be accompanied by loculicidal splitting of the pyrenes along the dorsal surface, and there may be others that we have not seen. Thus whilst the closest affinity appears to be with the Euphorbiaceae, in the absence of any information as to the structure of the seeds the reference must remain doubtful. We have placed it provisionally in the form-genus *Euphorbiotheca* under the name *E.* (?) *pentalocularis*.

V. 22513 Holotype, figured Pl. XII, figs. 17–19. A fruit represented by detached pyrenes. *Bowerbank Coll.*, Sheppey.

Genus EUPHORBIOSPERMUM nov.

DIAGNOSIS.—Seeds clearly referable to the family Euphorbiaceae, but of which the generic affinities are not known. The different species need not necessarily be closely related.

Euphorbiospermum eocenicum n. sp.

PLATE XII, figs. 20–25.

DIAGNOSIS.—Seed sub-globular, somewhat flattened at the chalazal end; chalaza a hollow cone, the flat surface facing inwards, the apex facing outwards; testa formed of an outer columnar coat of cells 0·02 mm. in diameter, a middle coat of large fusiform cells radially aligned with diaphanous walls, an inner coat of polygonal cells 0·7 mm. in diameter. Diameter, 5 to 7·5 mm.

HOLOTYPE.—V. 22514.

DESCRIPTION.—*Seed:* Sub-globular, somewhat flattened at one end; anatropous, the chalaza being at the flattened end and the hilum at the opposite end (raphe not seen); chalaza forming a hollow conical cap (now filled with pyrites) (Pl. XII, fig. 25), the apex turned outward and lying beneath a slight depression on the outer surface of the seed, the flat base being continuous with the innermost layer of the testa; both surfaces of the conical chalaza are striate, the striations radiating in the one case from the centre of the base, in the other from the apex of the cone, to the margin of the base; course of raphe indicated by a small scar or a short circular canal at the chalazal end (Pl. XII, figs. 20, 23) which marks its passage through the second coat; testa formed of three coats: (1) the outer (0·2 mm. thick) formed of fine close cells (0·02 mm. in diameter) with columnar arrangement as seen in radial sections of the seed, the columns in the neighbourhood of the chalaza being curved and oblique; (2) the middle coat (0·6 mm. thick) formed of large, extremely thin-walled, inflated fusiform or elongate cells radially aligned (usually perished); (3) the inner coat formed of large, flat, thin-walled, sharply angular polygonal cells, sometimes with a black secretion, of very variable shape and somewhat variable size (averaging about 0·7 mm. in diameter). Diameter of various seeds, 5, 6·5, 7, and 7·5 mm.

REMARKS.—Twelve specimens, including one from Herne Bay. There is a marked tendency for the seeds to show a three-partite arrangement at the hilar end, exemplified on the internal seed-casts by three diverging ridges of pyrites (Pl. XII, fig. 21). In the specimen taken as the type, the remains of the testa in contact with the ridges show in a transverse fracture of the seed that they represent incipient cracks (planes of weakness) into which pyrites has infiltrated. In most specimens the softer testa has been worn away, leaving the ridges remaining. The cells of the middle coat are so thin-walled and flimsy that they are only preserved when filled with pyrites, and even then are frequently torn and obliterated, so that few specimens show any trace of this coat. On those specimens which are the internal casts of the outer (columnar) coat of the testa, the chalaza shows as a small circular depression (Pl. XII, fig. 20), or as a short canal (Pl. XII, fig. 23) representing the section through the raphe-canal (the raphe having now disappeared) near the outer end of the chalaza. As we have already seen, there is a considerable interval between the apex and base of the chalazal cone. The meaning of this structure will be best understood and explained when we come to consider the affinity of the species.

Affinities.—The curvature of the cells in the columnar coat of the testa at once suggested affinity with the Euphorbiaceae. The difficulty was to find seeds which showed the large radially aligned fusiform cells of the middle coat of the testa, the curious large conical chalaza, and the globular form, for most living euphorbiaceous seeds are longer than broad or are more or less roundly triangular in transverse section. The seeds of *Cleidion javanicum* Blume, from Ceylon, in our own seed collection, first gave us the clue to the affinity, an affinity subsequently confirmed in Kew Herbarium. *Cleidion* has the outer coat of the testa hard and woody, and formed of cells with a columnar alignment, the columns being curved and oblique. Within this coat is one of large, soft, hyaline cells radially aligned. Over the chalaza this coat divides into an outer and an inner layer so as to form a hollow cone; the outer layer adheres to the columnar coat; the inner to the surface of the innermost coat which covers the albumen, the conical space between being empty. In the fossil the hollow thus formed has been filled with pyrites which forms a conical structure. In *C. javanicum* at the hilar end are three slight, divergent ridges; whilst sectioning a seed of this species along one of these ridges, it split along one of the others, showing that they must represent planes of weakness, as evidently they did in the fossil. Although *C. javanicum* is larger than the fossil (9 mm. long), other species of *Cleidion* are of the same size. Nevertheless, in spite of this close relationship between the fossil and the genus *Cleidion*, it cannot definitely be referred to the genus, because a thick middle coat of thin-walled cells occurs in a few other genera belonging to the section Acalypheae of Pax (1914), to which *Cleidion* belongs, and traces of a similar but thinner coat were found in other sections of the Euphorbiaceae. Still the resemblance of characters in *Cleidion* is so close that it seems highly probable that at least the fossil belongs to the section Acalypheae, although in view of the great size of the family and the limited opportunity which we have had of studying it, we cannot be quite certain on this point. We have therefore placed it in the form-genus *Euphorbiospermum* under the name *E. eocenicum*. *Cleidion* is a genus of leafless trees inhabiting the tropics of Asia, Africa, and America.

V. 22514 Holotype, figured Pl. XII, figs. 20–22. A seed, now fractured into three pieces. It shows the curved prismatic cells of the testa, the thin-walled tissue inside the columnar coat, the chalazal scar and the triradiate splitting of the testa from the hilum. *Reid & Chandler Coll.*, Minster, 1929.

V. 22515 Figured Pl. XII, figs. 23, 24. A seed-cast, with remains of the testa. The course of the inner end of the raphe to the chalaza is seen as a small round cavity or short canal where the testa has been abraded from the chalazal end of the seed. *D. J. Jenkins Coll.*, Herne Bay.

V. 22516 Figured Pl. XII, fig. 25. A seed, fractured longitudinally to show the inner coat of the testa and the large chalazal scar. *Bowerbank Coll.*, Sheppey.

V. 22517 Nine seeds, some fractured. *Reid & Chandler Coll.*, Minster, 1929.

Euphorbiospermum subquadratum n. sp.

Plate XII, figs. 26, 27.

Diagnosis.—Seed roundly quadrate, slightly compressed dorsi-ventrally; the hilar facet has two hollows; it extends almost the width of the seed, and makes an angle of about 130° with the ventral face ; cells of columnar coat of testa 0·02 mm. in diameter. Length, 12 mm.

HOLOTYPE.—V. 22518.

DESCRIPTION.—*Seed:* Anatropous, with hilum and chalaza at opposite ends ; roundly quadrate, somewhat compressed dorsi-ventrally, obliquely faceted at the hilar end on the ventral face, the plane of faceting making with the plane of the ventral surface an angle of about 130° (Pl. XII, fig. 27) ; this hilar facet, which is nearly as broad as the width of the seed, and about 4 mm. long, is hollowed into two very shallow depressions flanking a slight median elevation (Pl. XII, fig. 26) ; it was probably associated with an aril ; testa about 0·2 mm. thick, formed of an outer coat of polygonal cells, about 0·02 mm. in diameter, with columnar arrangement, the prisms being oblique or curved near the hilum ; and an inner coat of irregularly polygonal cells about 0·071 mm. in diameter. Length of seed, 12 mm. ; breadth, 11 mm. ; thickness, 7 mm.

REMARKS.—One seed, an internal cast of the testa to which remains of the testa cling in many places, especially around the hilum. Its surface shows at the chalazal end much-worn grooves radiating from a centre. These must represent the impressions of the fibres which radiate in the same manner from the chalaza within the testa of many Euphorbiaceae. The surface of the cast shows in many places the impressions of the inner ends of the small columnar testa cells with the much larger impressions of the cells of the inner coat of the testa superposed upon them.

AFFINITIES.—Every character of the seed indicates alliance with Euphorbiaceae. It belongs to one of the species with large seeds, but for the reasons stated on p. 283 no reference to a living genus can be made. We have therefore placed the specimen in the form-genus *Euphorbiospermum* under the name *E. subquadratum.*

V. 22518 Holotype, figured Pl. XII, figs. 26, 27. A seed. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum truncatum n. sp.

PLATE XII, figs. 28, 29.

DIAGNOSIS.—Seed truncately ovoid, not dorsi-ventrally compressed ; truncately faceted at the hilar end, the truncate and ventral faces making an angle of 85° ; cells of columnar coat of testa, 0·033 mm. in diameter ; cells of inner coat, 0·125 mm. in diameter. Length, 8 mm. ; breadth, 7 mm. ; dorsi-ventral thickness, 6·5 mm.

HOLOTYPE.—V. 22519.

DESCRIPTION.—*Seed:* Anatropous, with hilum and sub-terminal chalaza at opposite ends ; truncately ovoid, not dorsi-ventrally compressed ; truncately faceted at the hilar end, the plane of faceting, which makes an angle of about 85° with the ventral surface (Pl. XII, fig. 29), being about 6 mm. broad and 4 mm. long and having two shallow but well-marked depressions (hence the seed was probably arillate) ; testa about 0·2 mm. thick, or perhaps rather thicker in parts, formed of an outer coat of polygonal cells, about 0·033 mm. in diameter, which have a curved columnar arrangement as seen in section ; inner coat of irregular polygonal cells about 0·125 mm. in diameter. Length of seed, 8 mm. ; breadth, 7 mm. ; thickness (dorsi-ventral), 6·5 mm.

Remarks and Affinities.—Two specimens. The better of these is the internal cast of a seed with some of the testa preserved. At the rounded (chalazal) end is the foramen by which the raphe passed through the testa to the inner chalaza. The surface shows clearly the impressions of the cells forming both coats of the testa (Pl. XII, fig. 29), but the testa itself is much worn and smudged so that it is difficult to find a section showing more than a general effect of striation in the columnar layer, the cells being mostly obliterated. Nevertheless the relationship to Euphorbiaceae is clearly shown by the form of the seed, as well as such indications of the structure of the columnar coat as can be seen.

We have named the species *Euphorbiospermum truncatum*. It differs from *E. subquadratum* in its smaller size, the absence of compression, the almost rectangular truncation of the hilar facet and the larger cells of the columnar coat of the testa.

V. 22519 Holotype, figured Pl. XII, figs. 28, 29. Cast of a seed with remains of testa. *Bowerbank Coll.*, Sheppey.
V. 22520 Cast of a shrunken seed which may belong to this species, showing the branching fibres of the chalaza. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum obliquum n. sp.

Plate XII, figs. 30, 31.

Diagnosis.—Seed ovoid, not compressed, faceted at the hilar end, the facet and ventral face making an angle of 110°; cells of columnar coat, 0·02 mm. in diameter; cells of inner coat, 0·066 mm. in diameter. Length, 8·5 mm.; breadth, 6·5 mm.; dorsi-ventral thickness, 6 mm.

Holotype.—V. 22521.

Description.—*Seed:* Anatropous, with hilum and chalaza at opposite ends; ovoid, not compressed, faceted at the hilar end, the facet which makes an angle of 110° with the ventral face (Pl. XII, fig. 31) being about 6 mm. broad and 4 mm. deep and being medianly divided by a slight ridge, the two sides sloping from the ridge but scarcely hollowed (the seed was therefore probably arillate) (Pl. XII, fig. 30); chalaza marked by a circular black scar from which the testa cells radiate; testa (as preserved) about 0·1 mm. thick; outer coat of polygonal cells, 0·02 mm. in diameter, which have a columnar arrangement, the columns being curved; inner coat of irregular polygonal cells about 0·066 mm. in diameter. Length of seed-cast, 8·5 mm.; breadth, 6·5 mm.; dorsi-ventral thickness, 6 mm.

Remarks and Affinities.—One specimen, the internal cast of a seed to which a small portion of the testa adheres. The characters are unmistakably those of the Euphorbiaceae. It differs from *E. subquadratum* in its smaller size, in the absence of compression, in its more ovoid form, and in the more obtuse truncation of the hilar end. From *E. truncatum* it differs chiefly in the more acute truncation of the hilar end and the greater fineness of its cells. Two other specimens, much broken and larger, show cells of the same size; but the evidence is inadequate to refer them definitely to this species.

V. 22521 Holotype, figured Pl. XII, figs. 30, 31. Internal cast of a seed with remains of testa. *Bowerbank Coll.*, Sheppey.

V. 22522 Two damaged seed-casts which may belong to this species. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum obtusum n. sp.

PLATE XII, figs. 32, 33.

DIAGNOSIS.—Seed truncately ovoid, slightly compressed dorsi-ventrally, hilar facet making an angle of 100° with the ventral face; cells of the columnar coat of testa, 0·016 mm. in diameter; cells of inner coat, 0·05 mm. in diameter. Length of seed, 9 mm.; breadth, 8 mm.; dorsi-ventral thickness, 6·2 mm.

HOLOTYPE.—V. 22523.

DESCRIPTION.—*Seed:* Anatropous, with hilum and chalaza at opposite ends; truncately ovoid, slightly flattened dorsi-ventrally, the hilar facet, which makes an angle of about 100° with the ventral face (Pl. XII, fig. 33), sublunate without any median ridge; chalaza seen as a depression from which the testa cells radiate; columnar coat of testa about 0·2 mm. thick, the columns being oblique in parts, formed of polygonal cells 0·016 mm. in diameter; the inner coat formed of irregular polygonal cells with an average diameter of about 0·05 mm. Length of seed-cast, 9 mm.; breadth, 8 mm.; dorsi-ventral thickness, 6·2 mm.

REMARKS AND AFFINITIES.—One specimen, the internal cast of a seed to which part of the testa adheres. On its surface the impressions of the cells forming both coats can be seen. The combined characters above described refer it definitely to the Euphorbiaceae, and at the same time distinguish it from other species found in the London Clay. We have named it *Euphorbiospermum obtusum.*

V. 22523 Holotype, figured Pl. XII, figs. 32, 33. Cast of seed with remains of testa. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum subovoideum n. sp.

PLATE XII, figs. 34–36.

DIAGNOSIS.—Seed sub-ovoid, hilar facet forming an angle of from 120° to 130° with the ventral face; columnar coat of testa formed of cells 0·01 mm. in diameter; cells of inner coat, 0·025 mm. in diameter. Length of seed-cast, 4·5 mm.; breadth, 3·75 mm.; dorsi-ventral thickness, 3 mm.

HOLOTYPE.—V. 22524.

DESCRIPTION.—*Seed:* Anatropous, with hilum and chalaza at opposite ends; sub-ovoid, somewhat compressed dorsi-ventrally, in dorsi-ventral view rounded, slightly flattened or emarginate at the chalazal end, hilar facet, which makes an angle of from 120° to 130° with the ventral face (Pl. XII, fig. 35), small, medianly divided by a conspicuous ridge into two deep depressions (Pl. XII, figs. 34) (probably, therefore, arillate); chalaza seen as a circular impression from which the testa cells radiate (Pl. XII, fig. 36); testa (much abraded in the only specimen on which it is preserved) formed of a columnar coat with cells 0·01 mm. in diameter; and an inner coat of polygonal cells 0·025 mm. in diameter (the cells of both coats were measured by their impressions). Length of seed-cast, 4·5 mm. ; breadth, 3·75 mm. ; dorsi-ventral thickness, 3 mm.

REMARKS AND AFFINITIES.—Three specimens. The two which are most perfect in shape are completely devoid of the testa. The third, although collapsed and distorted, shows the abraded testa preserved in hollows on the surface. The characters are those of the Euphorbiaceae, but in combination differentiate it from other London Clay species. We have named the species *Euphorbiospermum subovoideum*.

V. 22524 Holotype, figured Pl. XII, figs. 34, 36. Internal cast of seed. *Bowerbank Coll.*, Sheppey.
V. 22525 Figured Pl. XII, fig. 35. A second internal cast. *Bowerbank Coll.*, Sheppey.
V. 22526 Internal cast of shrunken seed with remains of testa. *Reid & Chandler Coll.*, Minster, 1929.

Euphorbiospermum ambiguum n. sp.

PLATE XIII, figs. 1, 2.

DIAGNOSIS.—Seed sub-ovoid, the lateral margins sub-parallel, the chalazal end roundly truncate, the hilar facet making an angle of 130° with the ventral face ; cells of inner coat of testa 0·04 mm. in diameter. Length of seed-cast, 5·5 mm. ; breadth, 5 mm. ; dorsi-ventral thickness, 3·8 mm.

HOLOTYPE.—V. 22527.

DESCRIPTION.—*Seed:* Anatropous, with hilum and chalaza at opposite ends ; sub-ovoid, the lateral margins parallel, the base roundly truncate, the hilar end obtusely pointed, hilar truncation, which makes an angle of about 130° with the ventral face (Pl. XIII, fig. 2), divided into two small lateral depressions by a median ridge (Pl. XIII, fig. 1), probably indicating that the seed was originally arillate ; columnar coat of testa not preserved, and the cell-impressions too obscure for measurement ; inner coat formed of cells 0·04 mm. in diameter. Length of seed-cast, 5·5 mm. ; breadth, 5 mm. ; dorsi-ventral thickness, 3·8 mm.

REMARKS AND AFFINITIES.—Three internal casts of seeds without the testa, the surfaces being so worn that only on one is there any trace of cell-impressions.

The form of the seed, faceted at the hilar end, the facet being medianly divided so as to form two slight hollows, places these specimens in the Euphorbiaceae. It is distinguished from *E. subovoideum*, which it most resembles, by the nearly parallel lateral margins and by the greater size of the cells forming the inner coat of the testa. We have given it the name *E. ambiguum*, as it has no outstanding features.

V. 22527 Holotype, figured Pl. XIII, figs. 1, 2. Internal cast of a seed. *Bowerbank Coll.*, Sheppey.
V. 22528 Two poorly preserved seed-casts. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum latum n. sp.

PLATE XIII, figs. 3, 4.

DIAGNOSIS.—Seed with dorsal and ventral faces sub-circular in outline, dorsi-ventrally compressed, hilar truncation making an angle of 120° with the ventral face ; cells of columnar coat of testa, 0·012 mm. in diameter ; cells of inner coat, 0·025 mm. in diameter. Length of seed, 4·5 mm. ; breadth, 4·7 mm. ; dorsi-ventral thickness, 3·5 mm.

Holotype.—V. 22529.

Description.—*Seed:* Anatropous, with hilum and chalaza at opposite ends; sub-ovoid with dorsal and ventral faces sub-circular in outline, slightly emarginate at the chalazal end, hilar facet, which makes an angle of about 120° with the ventral face (Pl. XIII, fig. 4), small, divided by a well-marked ridge into two small lateral depressions (Pl. XIII, fig. 3), probably indicating an aril; outer coat of testa (0·05 mm. thick) formed of cells about 0·012 mm. in diameter, columnar, the columns oblique; inner coat of cells, 0·025 mm. in diameter. Length of seed, 4·5 mm.; breadth, 4·7 mm.; dorsi-ventral thickness, 3·5 mm.

Remarks and Affinities.—Two specimens. Both were originally perfect with the testa preserved, although one had somewhat collapsed on the ventral face. This seed was eventually fractured and the curved columnar cells of the testa were then shown. The other specimen shows the external chalaza as a circular, depressed, somewhat worn area in the thickness of the testa. Again, the characters of form and cell-structure are distinctive of the Euphorbiaceae and we have referred the specimens to that family under the name *Euphorbiospermum latum* on account of the great breadth of the seed.

V. 22529 Holotype, figured Pl. XIII, figs. 3, 4. Seed with testa. *Reid & Chandler Coll.*. Minster, 1929.
V. 22530 A seed, now broken in pieces. *Bowerbank Coll.*, Sheppey.

Euphorbiospermum crassitestum n. sp.

Plate XIII, figs. 5–7.

Diagnosis.—Seed sub-ovoid, pointed at the hilar end, ventral face somewhat ventricose, hilar facet making an angle of 120° or 140° with the ventral face; cells of columnar coat of testa 0·025 mm. in diameter; cells of inner coat 0·066 mm. in diameter. Length of seed, 11 to 12 mm.; breadth, 9 to 10 mm.; dorsi-ventral thickness, 8 to 8·5 mm.

Holotype.—V. 22531.

Description.—*Seed:* Anatropous, with hilum and chalaza at opposite ends; sub-ovoid, markedly pointed at the hilar end (Pl. XIII, fig 6), and with the ventral face somewhat ventricose, hilar facet, which makes an angle of 120° with the ventral face in one specimen and 140° in the other, shallow, as seen on the internal cast, divided by a short but sharp median ridge into two shallow depressions (Pl. XIII, fig. 5); the seed was probably therefore arillate; chalaza a small circular scar; testa 0·35 mm. thick; outer coat (formed of polygonal cells 0·025 mm. in diameter) columnar in section, the columns being curved; inner coat formed of polygonal cells 0·066 mm. in diameter. Length of seed, 11 to 12 mm.; breadth, 9 to 10 mm.; dorsi-ventral thickness, 8 to 8·5 mm.

Remarks and Affinities.—Two seeds, one with the testa much encrusted with pyrites, the other (holotype) with the testa somewhat abraded all over the surface. The shape, and the identity in character of the cells of the testa and tegmen, indicate that they both belong to the same species.

All the characters indicate a species of Euphorbiaceae. Seeds pointed at the hilar end may occur in the family; we have seen them, for example, in *Manihot Glaziovii* Muell., in which the seeds, although they somewhat resemble the fossils in shape and in the thickness of the testa, are flatter.

V. 22531 Holotype, figured Pl. XIII, figs. 5, 6. A seed with testa somewhat abraded.
V. 22532 Figured Pl. XIII, fig. 7. A seed with testa preserved but somewhat obscured by an incrustation of pyrites. Labelled by Ettingshausen "*Faboidea* Bowerb."
Both are from the Bowerbank Coll., Sheppey.

Family EUPHORBIACEAE ?

Genus ? (carpel with two seeds)

PLATE XIII, figs. 8, 9.

DESCRIPTION.—*Carpel:* One of three ?, sub-circular in outline, roundly triangular in cross-section, with convex dorsal face, and flat ventral faces which meet at a rounded acute angle. Dehiscing at first septicidally and later loculicidally, two-seeded. External surface slightly rough, with indications of large polygonal cells on its surface. An inner coat, whether belonging to endocarp or seed we are uncertain, shows columnar structure in section. The carpel wall thins very markedly towards the inner margin on the lateral faces. Length of carpel, 2·66 mm.; breadth of dorsal face, 3·25 mm.; breadth of lateral faces, 2·25 mm.

REMARKS.—One specimen, preserved in calcite, from the Basement Bed of the London Clay at Harefield, Middlesex. The specimen was broken at one end, showing the two seeds within the locule. The surfaces of the seeds were much obscured by a film of iron oxide, and when an attempt was made to brush this off, the carpel at once broke loculicidally (Pl. XIII, figs. 8, 9) along what was evidently a plane of weakness, so that one seed lay in one half, and one in the other half. A small portion of the lateral wall of the carpel also broke near the exposed ends of the seeds, thus displaying more of their truncate ends and apparently rough surfaces, and showing, in a crack, the columnar cells of one of the coats in section. Owing to accretions of mineral matter, it is not possible to determine whether this coat belongs to endocarp or seed.

AFFINITIES.—The form of this two-seeded carpel and its mode of dehiscence, at first septicidal, and later loculicidal, and the truncate seeds, suggest a possible relationship with Euphorbiaceae. Such a relationship is supported by the columnar character of one coat. In some Euphorbiaceae, both endocarp and testa show a columnar arrangement in section, but whether all do we cannot say. If euphorbiaceous, it must belong to one of the two-seeded sub-sections, Phyllanthoideae, of the section Platylobeae, or Porantheroideae, of the section Stenolobeae. In the former sub-section several living genera have fruits and seeds comparable in size with the fossil.

V. 22533 Figured Pl. XIII, figs. 8, 9. A two-seeded carpel, from the Basement Bed of London Clay, Harefield, Middlesex. *H. A. Toombs Coll.*, 1931.

Family ANACARDIACEAE

Section SPONDIEAE (Engler)

Eleven species, all referable to the section Spondieae of the family Anacardiaceae, are found in the London Clay. In this section of the family the endocarps are woody, being formed of massive strands of fibres which twist, branch, and anastomose so as to form a framework, the interstices of which are packed with parenchyma. In many-loculed genera the locules surround a central axis, and in most genera (all ?) they open for germination by large round or oval apertures which are closed by plugs, sometimes of hard, sometimes of soft tissue, which form part of the endocarp. In one group of genera belonging to the section, besides these large apertures which communicate with the locules, there are other smaller ones which do not, but merely lead into the substance of the endocarp. Among the members of this group, in *Dracontomelon* Blume and *Pseudospondias* Engler, the small apertures are arranged in pairs, a pair between every two large ones, rather below the equator of the endocarp, so that there are twice as many small apertures as large ones. In *Sclerocarya* Holst and *Poupartia* Comm. the small apertures equal the large ones in number, but are at the base of the endocarp forming a ring around the attachment. It is to this group of genera that six out of the eleven species of Anacardiaceae in the London Clay are related; of three others whose relationship can be traced, two are definitely and the third doubtfully referable to *Odina*.

In order to facilitate the various discussions of relationship which will follow, it will be useful to state in a tabular form the characteristics of those living genera among this group of the Anacardiaceae which show relationship to the fossils of the London Clay.

Genus.	Number of locules.	Shape.	Number of small apertures.	Position of small apertures.	Surface of endocarp.
Dracontomelon	5	Lenticular.	5 pairs.	Below middle.	Rather rough and irregular.
Sclerocarya ..	Usually 3, sometimes 4.	Sub-globular, longer than broad, sometimes laterally compressed.	3 or 4 single.	Base.	Smooth.
Pseudospondias	3 or 4.	Rounded-cylindric or ovoid.	3 or 4 pairs.	Below middle.	Fairly smooth.
Spondias ..	5	Ovoid.	5 single.	Base.	Fairly smooth.
Poupartia ..	5	Ovoid.	5 single. Also longitudinal rows of small paired holes alternating with the locules.	Base.	Smooth.

Three only of the fossil species can be referred definitely to living genera of this group: two to *Dracontomelon*, and one to *Spondias*. Of the two species of

Dracontomelon, one, *D. subglobosum*, differs in form from any living species that we have met with, although in its other characters, which seem more essential, it agrees. In form it resembles *Sclerocarya*. This brings us to a curious phenomenon which we have observed among the London Clay Anacardiaceae. It is as though the features which characterise some members of this group of fossil genera had been reshuffled and recombined in the living genera. Thus in *Pseudosclerocarya lentiformis* and *P. subalata*, with the number of locules and shape belonging to *Dracontomelon*, there is an absence of the small paired apertures found in that genus; instead, there is a basal ring of small apertures as in *Sclerocarya*. Were it only one species that were in question we might have thought it was ancestral to the two living genera, but since it is three species, they must indicate collateral relationship, either generic or specific.

Crow (1810, No. 625) illustrates a fruit which must be referred to Spondieae, and probably to *Dracontomelon*. He comments upon the specimen "showing seed holes like a sand-box, very beautiful."

There are but few previous records of fruits referable to Spondieae. Langeron (1899, p. 25, pl. iii, figs. 2, 4) describes a fruit from Sézanne which he suggests may be related to *Spondias* on account of the four holes at one end. He names it *Spondiaecarpon dubium*, but regards the determination as doubtful because the specimen shows very definite regular ribs. As he points out, these are only seen in the living *Spondias* when the external pulp or fibres have not been removed, in which state the pores or apertures are not visible. In our opinion the appearance of the fruit is unlike that of *Spondias*, and we also regard the relationship as doubtful. In any case the specimen is very different in form and in the position of its apertures from the London Clay Spondieae.

Dr. N. Hartz also figures a fruit under the name *Carpolithes hafniensis* from the Amber Pine bed of Denmark which strongly suggests a relationship with *Sclerocarya* (1909, pp. 122, 278, pl. v, figs. 6 *a–c*). But in his description Dr. Hartz states that the fruit is one-loculed; if so, the external appearance is misleading as regards relationship.

Among fruits referable to Anacardiaceae, Menzel's *Spondiaecarpum turbinatum* (1913, pp. 6–9, pl. i, figs. 8–18) seems to belong to the Anacardiaceae, but is not related to any of the London Clay species, as might be expected from its much more recent date (Lower Miocene).

Genus DRACONTOMELON Blume

1850. Mus. Bot. Lugd. Bat., xlii, p. 231.

Dracontomelon subglobosum n. sp.

Plate XIII, figs. 10–19; text-fig. 6.

Diagnosis.—Endocarp sub-globose, or occasionally sub-lenticular, roundly pentangular, surface smooth. Length, 8 to 11 mm.; diameter, 8 to 12 mm. Seed half-anatropous. Length, 8 mm.; dorsi-ventral breadth, 2·8 mm.; tangential thickness, 1 mm.

HOLOTYPE.—V. 22534.

DESCRIPTION.—*Endocarp:* Usually sub-globose with the greatest circumference at the middle, occasionally sub-lenticular, more or less roundly pentangular, smooth externally, attached basally, with five one-seeded locules symmetrically placed around a central axis and opening to the exterior by large apertures closed by plugs arranged in a circle between the apex and equator of the endocarp (Pl. XIII, figs. 10–12), also below the equator with a ring of paired smaller (although large) apertures, twice as many as the number of locules (Pl. XIII, fig. 10), which do not communicate with the locules but only with the substance of the endocarp (Pl. XIII, fig. 16); locules elongate longitudinally, compressed tangentially, broad, truncate, and slightly curved or crooked above, so that the upper end opens to the exterior (save that it is closed by a plug); much narrowed below (Pl. XIII, fig. 16), where the endocarp is very thin. The locule is completely filled by the

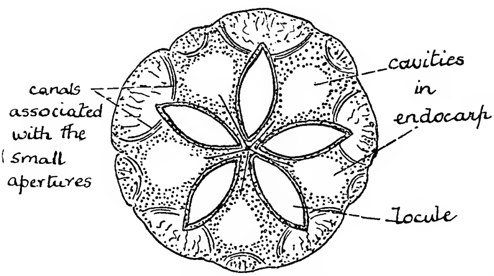


FIG. 6.—*Dracontomelon subglobosum.* Endocarp; transverse section (diagrammatic), to show the lacunae between the locules. The section does not lie in the plane of the small apertures; hence, although their presence is indicated by the structure, the associated canals are not seen to connect with the locule-lining.

pendulous seed which is fused with the plug and partly fused with the locule-lining, so that on germination both plug and part of the locule-lining are extruded with the seed; endocarp formed of parenchyma (cells about 0·025 mm. in diameter) in which strands of fibres are embedded; within its substance, alternating with the locules, are large lacunae (text-fig. 6; cf. also Pl. XIII, fig. 17); towards the locule the parenchyma forms closely compacted layers the cells of which are horizontally aligned; the locule is lined by a layer of cells with sinuous or digitate outlines. Length of endocarp, 8 to 11 mm.; diameter, 8 to 12 mm.

Seed: Conforming in shape to the locule (*q.v.* above; also Pl. XIII, fig. 19), half-anatropous with the hilum at the truncate end, raphe and chalaza dorsal, the latter circular, about 1 mm. in diameter, situated midway along the dorsal (concave) margin (Pl. XIII, fig. 19); testa formed externally of polygonal cells 0·016 mm. in diameter, internally of elongate cells (0·015 mm. broad) which radiate from the chalaza but elsewhere form longitudinal striations, whilst between these layers is a thickness of square or polygonal cells about 0·015 mm. in diameter. Length of seed, 8 mm.; dorsi-ventral breadth, 2·8 mm.; tangential thickness, 1 mm.

REMARKS.—About twenty endocarps and a number of fragments from Sheppey, and two specimens from Herne Bay. The endocarps are usually a good deal worn. Sometimes, near the base, where the endocarp is thin, it may be so much worn that the narrow ends of the seeds, or locule-casts, may protrude (Pl. XIII, fig. 16). Or, again, the plugs may have been worn away, or may have fallen out (Pl. XIII, figs. 12, 14) so that the locule-casts or seeds are exposed. In the former case, when they are worn away, a median longitudinal groove is sometimes visible on the truncate end of the locule- or seed-cast (Pl. XIII, figs. 11, 12). This groove is the impression of the raphe (or funicle ?) crossing the end of the seed to the dorsal margin. The locule-lining, as we have seen, adheres to the surface of the seed, or it may adhere to the pyrites which has infiltrated between them. Consequently it is difficult to see the digitate cells of the locule-lining; since they are often exposed only in small patches which are easily lost and cannot be rediscovered, or as obscure impressions, it has not been found possible to measure the digitate cells; and the same is true of others of the Spondieae to be described. The seed-cast, when exposed, often has patches of testa adhering and frequently the chalaza is visible (Pl. XIII, fig. 19).

AFFINITIES.—The characters of these remarkable endocarps leave no doubt that they belong to the Spondieae (Engler) of the family Anacardiaceae. By reference to the table on p. 298 in which the salient characters of comparable fruits are given, it will be seen that the fossil shows almost all the characters of *Dracontomelon* except shape. The fruits of *Dracontomelon* are lenticular, while the fossil fruits are sub-globose, although a few specimens show an approach to the lenticular form. In their form as typically developed, and in the smoothness of the surface of both endocarps and plugs, the fossils agree more nearly with *Sclerocarya*, from which they differ in the number of their locules (five, as against three or four in *Sclerocarya*) and in the presence of paired apertures as described above. It is clearly to these two genera that the fossil is most closely related, and the characters which connect it with *Dracontomelon* and dissociate it from *Sclerocarya* appear to us more important than those which suggest the opposite association. That is, the number of locules and the ring of paired holes appear to us to be, judging by living forms, more essential characters than the difference of shape and degree of smoothness.

Dracontomelon is a genus of large trees sometimes 50 to 60 feet high, which inhabit the tropics of eastern Asia, from Indo-China and Siam to Polynesia, growing in dense jungle and evergreen forests, often by rivers.

V. 22534 Holotype, figured Pl. XIII, fig. 10. An endocarp showing the five carpels and the ten small apertures between them.
V. 22535 Figured Pl. XIII, fig. 11. An endocarp, figured to show the apex.
V. 22536 Figured Pl. XIII, fig. 12. An endocarp showing empty locules from which the seeds have fallen.
V. 22537 Figured Pl. XIII, fig. 13. An endocarp figured to show the base.
V. 22538 Figured Pl. XIII, fig. 15. An endocarp which has been abraded so as to expose the casts of the locules at the surface.

V. 22539 Figured Pl. XIII, fig. 16. An endocarp fractured longitudinally. The section passes through the locules and through one of the small paired apertures.
V. 22540 Figured Pl. XIII, fig. 17. An endocarp fractured transversely, showing the locules and the character of the carpel wall.
V. 22541 Figured Pl. XIII, fig. 18. A plug detached from an endocarp. Also the remains of the endocarp.
V. 22542 Figured Pl. XIII, fig. 19. A seed dissected from an endocarp. It shows the chalaza.
V. 22543 Ten fruits, and fragments or large pieces of at least ten others.
All the above are from the Bowerbank Coll., Sheppey.
V. 22544 Three poor and imperfect fruits. *Reid & Chandler Coll.*, Minster, 1929.
V. 22545 Two specimens; one is abraded so that the locule-casts are exposed. *D. J. Jenkins Coll.*, Herne Bay.

The specimen figured Pl. XIII, fig. 14, has decayed since it was photographed; it showed, more clearly than any other fruit, the fibrous surface and the sharply defined aperture left by the removal of a plug and seed (or locule-cast). It was labelled "*Hightea* Bow." by Ettingshausen.

Dracontomelon minimum n. sp.

PLATE XIII, figs. 20–24.

DIAGNOSIS.—Endocarp lenticular, roundly pentangular, very small, surface smooth. Length, 2·5 to 4·3 mm.; diameter, 4·6 to 7·3 mm. Seed anatropous. Length, 4·6 mm.; breadth at plug, 3·5 mm.

HOLOTYPE.—V. 22546.

DESCRIPTION.—*Endocarp:* Roundly pentangular, lenticular, the lower surface being convex and the upper truncately pyramidal, with five one-seeded locules symmetrically placed around a central axis and opening to the exterior by large oval apertures closed by parenchymatous plugs which form a circle between the apex and equator of the endocarp (Pl. XIII, figs. 20, 22, 23), also below the equator a ring of paired very small apertures (Pl. XIII, fig. 23) twice as many as the number of locules, which do not communicate with the locule but only with the substance of the endocarp; locules sub-triangular in longitudinal section, tangentially compressed (Pl. XIII, fig. 24), broad and obliquely truncate above, narrowed below, shorter and broader in proportion than the locules of *D. subglobosum;* endocarp formed of uniform parenchyma (the cells about 0·025 mm. in diameter except around the locules where they are much smaller) within which, in the axial region, are many strands of fibres which at the apex unite into five bundles and pass downwards within the parenchyma towards the equator; around the locules the endocarp is formed of several layers of transverse fibres, but the locule is lined by digitate interlocking cells elongate longitudinally which form a smooth shining longitudinally striate surface. Length of endocarps, from 2·5 to 4·3 mm.; diameter, 4·6 to 7·3 mm.

Seed: Similar in shape to the locule (*q.v.* above); anatropous, with hilum at the broad truncate end, raphe dorsal, chalaza, relatively larger than that of *D. subglobosum*, basal on the dorsal margin (Pl. XIII, fig. 24); testa formed of an outer coat of flat, equiaxial, polygonal cells 0·012 mm. in diameter, and an inner coat of elongate parallel-sided cells with faceted or bevelled ends aligned longitudinally and forming a striate surface, striae about 0·012 mm. apart. Length of an average seed, about 4·6 mm.; greatest breadth (at the plug), 3·5 mm.

Remarks and Affinities.—Thirty-eight specimens, all found by ourselves at Minster. Some were much worn and the plugs had come away, so that the locule-casts were exposed, or, in one or two cases, had fallen out. In some specimens the five vascular bundles have resisted abrasion and stand out as ribs on the worn surface, diverging from the apex over the upper surface of the endocarp. Some of the specimens we have fractured for study.

The species must undoubtedly be referred to *Dracontomelon*. The form and characters are typical of that genus. The most marked of the differentiating characters are the unusually small size and the smoothness of the endocarp, and the small size of the paired apertures. These are usually so obscure that they can be seen only with the greatest difficulty.

V. 22546 Holotype, figured Pl. XIII, figs. 20–22. An endocarp.
V. 22547 Figured Pl. XIII, fig. 23. An endocarp. It shows the small paired holes very clearly in one place.
V. 22548 Figured Pl. XIII, fig. 24. An endocarp fractured longitudinally. One of the seeds shows the basi-dorsal chalaza.
V. 22549 Thirty-five specimens, a few fractured longitudinally.
All are Reid & Chandler Coll., Minster, 1929.

Genus PSEUDOSCLEROCARYA nov.

Diagnosis.—Endocarps, referable to the Spondieae, bony, lenticular, with five one-seeded locules placed symmetrically around the axis and opening by large apertures which are closed by bony plugs and form a ring between the apex and equator, also with five small basal apertures encircling the attachment and alternating with the large ones; formed of parenchyma with embedded strands of fibres which branch and anastomose over the whole surface to form a network.

Genotype.—*P. lentiformis* n. sp.

Pseudosclerocarya lentiformis n. sp.

Plate XIII, figs. 25–28.

Diagnosis.—Endocarp with a thick marginal rim. Length, 7 mm.; diameter, 13 to 14 mm.

Holotype.—V. 22550.

Description.—*Endocarp:* Lenticular, circular in outline, with five one-seeded locules, the locules opening by five large oval apertures, closed by plugs, which reach nearly from the apex to the equator and are arranged in a circle round the fruit (Pl. XIII, fig. 25), encircling the attachment are five small obscure apertures alternating with the larger apertures; endocarp formed of a framework of woody fibres, the interstices being filled by woody parenchyma (cells 0·025 mm. in diameter); the framework is formed by large strands of fibres which diverge both from base and apex (five from each), the strands from the apex, after completely encircling the large apertures and covering the surface and the substance of the parenchyma with a meshwork of fibres, pass to the margin where they bifurcate; here they meet with a similar system of fibres formed by the five more slender basal strands which also bifurcate at the margin alternately with them, the fibres of the two systems uniting to form a strong marginal rim (Pl. XIII, fig. 27); locule lined by digitate cells (preserved only as obscure impressions) transversely elongate (greatest diameter about 0·05 mm.), which sometimes produce transverse striations. Length of endocarp, 7 mm.; diameter, 13 to 14 mm.

Seed: Conforming to the locule in shape, longer than broad, flattened under the plug, narrowed towards the base of the fruit, pendulous, half-anatropous, hilum near the plug, raphe dorsal, chalaza large, circular, about half-way down the dorsal margin; testa thin, rough externally (cells not clearly seen), smooth and striate internally, the striations, which diverge from the chalaza, produced by elongate thin-walled cells about 0·012 mm. broad.

Remarks and Affinities.—Three endocarps, two of which are broken so as to expose the structure of the locule and seed. They must undoubtedly be referred to the section Spondieae (Anacardiaceae), but the question of generic relationship is more difficult, as will be seen by reference to the table, p. 298. A comparison of characters with those set forth in the table shows that the closest relationship is with *Dracontomelon* and *Sclerocarya*. In the number of locules, and in shape, the species agrees with *Dracontomelon*, but in the small, unpaired, basal holes it agrees with *Sclerocarya*. Such distinctions make it unwise to unite it with either of the two living genera. We have therefore referred this species, and the next, which shows the same characteristics, to a new genus under the name *Pseudosclerocarya*, which has been chosen because our observations show that the number of locules is rather an uncertain criterion of relationship and there is definite evidence that in several genera the number has been reduced with the passage of time. Shape, again, is a somewhat variable character among the Anacardiaceae, whereas in living genera we have found that the number, character, and position of the small apertures is a stable and persistent character. Therefore, rightly or wrongly, we have regarded the closer alliance as probably with *Sclerocarya*.

V. 22550 Holotype, figured Pl. XIII, figs. 25–27. An endocarp.
V. 22551 Figured Pl. XIII, fig. 28. An endocarp, fractured to show the locule-cast.
V. 22552 An endocarp, fractured to show seeds and locule-cast. It also shows the cells of the locule-lining.

All are from the Bowerbank Coll., Sheppey.

Pseudosclerocarya subalata n. sp.

Plate XIII, figs. 29–31.

Diagnosis.—Endocarp produced at the margin into a thin frilled flange. Length, 7 mm.; diameter, 20 mm.

Holotype.—V. 22553.

Description.—*Endocarp:* Lenticular, circular in outline, thinning markedly towards the slightly frilled margin so as to form a marginal flange, with five one-seeded locules opening by five large oval apertures, closed by plugs, which extend nearly from the apex to the equator, and are arranged in a circle round the fruit (Pl. XIII, fig. 29), basal apertures very obscure (showing but obscurely in one place only); endocarp formed exactly as in the last species by large bundles of fibres which diverge from base and apex, except that the fibres do not so markedly encircle the large apertures but cover them with a network, and that at the margin instead of forming a strong rib they break up into yet finer filaments which anastomose to form a very fine network over the frilled marginal flange (Pl. XIII, figs. 30, 31). Length of endocarp, 7 mm.; diameter, 20 mm.

Remarks and Affinities.—One specimen, clearly related to *P. lentiformis*, the evidence being so definite that we did not consider it necessary to section this unique and beautiful specimen. Whilst referring it to the same genus, we cannot refer it to that species, because it differs markedly in its larger size (20 mm. in diameter, as against 13 or 14 mm.), proportionally more compressed form, and in having a thin, flanged, and frilled margin instead of one bounded by a strong rib.

V. 22553 Holotype, figured Pl. XIII, figs. 29–31. An endocarp. *Bowerbank Coll.*, Sheppey.

Genus SPONDIAS Linn.

1737. Gen., ed. i, p. 365.

Spondias sheppeyensis n. sp.

Plate XIII, figs. 32–34.

Diagnosis.—Endocarp obovoid, less fibrous than those of *S. axillaris* Roxb. (which species most resembles it); locules greatly compressed tangentially. Length, 12 mm.; greatest diameter, 10 mm.; least diameter, 9 mm.

Holotype.—V. 22554.

Description.—*Endocarp:* Obovoid, with irregularly rounded contours, slightly compressed laterally (the effect of distortion ?), with five radially arranged one-seeded locules, longitudinally elongate and tangentially compressed, which communicate with the exterior by comparatively small oval apertures arranged in a ring about one-quarter of the length of the endocarp below the apex; no pairs of small apertures can be seen at the worn base, but conspicuous canals with fibrous walls have been broken into and these were probably associated with such apertures; endocarp formed mainly of granular parenchyma (cells from 0·05 to 0·1 mm. in diameter), within which, especially towards the exterior, are tortuous strands of fibres; the locule lined by equiaxial clawed and interlocking cells 0·066 mm. in diameter. Length of endocarp, 12 mm.; greatest diameter, 10 mm.; least diameter, 9 mm.

Seed: Conforming in shape to the locule, slightly concave on the dorsal margin, thicker tangentially at the end nearest the top of the fruit than at the other; testa formed externally of regular polygonal cells (0·016 mm. in diameter) approximately in longitudinal rows, internally of elongate cells (from 0·016 to 0·025 mm. broad) with sinuous walls due to irregular thickening. Length of seed, about 10 mm.; radial breadth, about 3 mm.; tangential thickness, from 1 mm. near the top of the fruit to 0·05 near the base.

Remarks.—One endocarp, part of which was much encrusted with pyrites. It was sectioned transversely near the base thus exposing the five compressed locules radiating from the axis of the fruit. In order to discover the form of the locules and seeds, and the structure of the seed-coats, the specimen was further fractured longitudinally, whereupon the structures described above were seen, but the chalaza was not exposed.

Affinities.—The relationship of this fruit to the section Spondieae of the family Anacardiaceae cannot be doubted. In form it most resembles *Sclerocarya*, *Spondias*, and *Poupartia*. The number of locules is greater than that found in the living genus *Sclerocarya*, and there are apparently no hard woody plugs as in that genus. *Poupartia* has similar but much wider locules than those of the fossil, and we can see no traces of the rows of small holes on the external surface intermediate between the locules, such as are found in that genus. There remains *Spondias*, and it is with this genus that the relationship is closest; except for the smaller size of the fossil compared with those living species which we have been able to examine, the resemblance seems complete. The most nearly allied species appears to be *S. axillaris* Roxb. (= *S. lutea* Roxb.). In this the endocarp measures 18 × 13·5 mm., the locules are rather broader in proportion than those of the fossil, and the walls are more fibrous. The basal apertures are often obscure, but when developed they open into the interspaces between the locules. We have no hesitation in referring the fossil to *Spondias*, under the name *S. sheppeyensis*. The genus *Spondias* inhabits the tropics of the Old and New Worlds. *S. axillaris* Roxb. occurs in the tropics of the whole world.

V. 22554 Holotype, figured Pl. XIII, figs. 32–34. An endocarp, now fractured transversely and longitudinally. *Bowerbank Coll.*, Sheppey.

Genus SPONDICARYA nov.

Diagnosis.—Endocarp sub-ovoid, three-angled; with three elongate one-seeded locules, tangentially compressed, semi-oval in outline, and radially arranged around a central axis; endocarp formed of parenchyma with interbedded fibres. Length of endocarp (as preserved), 5·4 mm.; diameter, 5 mm. Length of locule, 5·3 mm.; radial breadth, 2·4 mm.; tangential thickness, 1·4 mm. Seed flattened, semi-oval in outline, with straight ventral and convex dorsal margin, the dorsal margin emarginate medianly at the large, circular, somewhat asymmetrically placed chalaza; inner coat of testa with striae radiating from the chalaza.

Genotype.—*S. trilocularis* n. sp.

Spondicarya trilocularis n. sp.

Plate XIII, figs. 35, 36.

Diagnosis.—That of the genus.

Holotype.—V. 22555.

Description.—*Endocarp:* Sub-ovoid, roundly three-angled (probably three-lobed originally), with three one-seeded locules, one in each lobe; locules semi-oval in outline, with straight ventral and convex dorsal margins, much compressed tangentially, broader towards the axis than towards the periphery of the fruit, especially in the middle area where they narrow considerably near the dorsal margin between rounded latero-dorsal tumidities (which correspond in position with a dorsal emargination and lateral hollows over the chalaza of the seed); above and below these tumidities the dorsal walls are faceted and the locules are less compressed; endocarp very thick between the locules, formed of parenchyma with a tendency to radial alignment of its cells (0·3 mm. in diameter), and with longitudinal strands of fibres embedded (number unknown); also with a coat of fine transverse fibres surrounding the locules; locule lined by clawed interlocking cells (seen with great difficulty owing to longitudinal crumpling). Length of endocarp, 5·4 mm.; diameter, 5 mm.

Seed: Conforming to the shape of the locule with a median dorsal emargination; half-anatropous, the large round chalaza being situated at the dorsal emargination and placed asymmetrically so as to lie more on one side of the seed than the other (Pl. XIII, fig. 36); testa formed of square-ended cells with thickened lateral walls, short (or perhaps elongate), 0·02 mm. broad, aligned so as to form fine striations radiating from the chalaza in all directions, but gradually becoming longitudinal on the ventral margin. Length of seed (as measured by the length of the locule-cast), 5·3 mm.; radial breadth, 2·4 mm.; tangential thickness, 1·4 mm.

Remarks.—One specimen, perfect except that the surface was worn, especially over the angular lobes where abrasion had exposed the locule-casts. The endocarp was fractured along one of the locules, the flat face of the locule-cast being thereby exposed with the seed lying within it and still partly covered by the cast. When this was carefully chipped away the chalaza was seen, also the impressions of the cells forming the inner surface of the testa. These sometimes appear to be short and square, sometimes elongate. It is probable that they really are short, but that the impressions of the transverse walls are not always preserved.

Affinities.—The structure of this syncarpous endocarp and of its seed point definitely to an alliance with the section Spondieae of the family Anacardiaceae. It is smaller than the majority of living genera referable to this section, but it is not smaller than species of *Odina*. Whether it had germination valves or plugs we cannot say as, if they ever existed, they have now been removed by abrasion, but the broadening and marked faceting of the dorsal margin of the seed at the end near the apex of the fruit suggests the former presence of such valves or plugs. We cannot refer the specimen to *Odina*, because in *Odina* the seeds are quite markedly concave on the dorsal margin, so far as we have seen them, whereas the fossil is convex with only a slight emargination at the chalaza. In form the seeds are rather more like those of *Sclerocarya* and *Dracontomelon*, but we do not think that the endocarp can ever have had such definite hard germination plugs as are found in these genera. If it had plugs at all, they would probably have been masses of soft tissue closing the aperture for germination, as in *Odina*. The fossil endocarp is less fibrous than those of any species we have seen of the genera mentioned above, which is another reason for not referring it to any of them. We have, therefore, given it the distinctive name *Spondicarya trilocularis*.

V. 22555 Holotype, figured Pl. XIII, figs. 35, 36. An endocarp, much abraded, and now fractured to show locule-casts and seeds. *Reid & Chandler Coll.*, Minster, 1929.

Genus ODINA Roxb.

1814. Hort. Beng., p. 29.
1832. Fl. Ind., II, p. 293.

Odina Jenkinsi n. sp.

Plate XIII, figs. 37–40.

Diagnosis.—Endocarp one-loculed, one-seeded, much compressed laterally. Length, 8 mm.; breadth, 4·3 mm.; dorsi-ventral thickness, 1·6 mm. Seed less markedly arcuate or reniform than in many living species.

Holotype.—V. 22556.

Description.—*Endocarp:* Ovate in outline with one margin convex and the other straight below, but obliquely truncate above, much compressed laterally; one-loculed, one-seeded; formed of massive strands of fine hard woody fibres which coil and branch, enclosing large deep hollows (now filled with pyrites), about ten on each face (Pl. XIII, fig. 37), around the truncation this coat is wanting (indicating in all probability an area of weakness connected with germination as in *Odina*); locule lined by two (?) layers of elongate cells (probably digitate) with black contents (cells seen only in section). Length of endocarp, 8 mm.; breadth, 4·3 mm.; thickness, 1·6 mm.

Seed: Arcuate in profile (Pl. XIII, figs. 38, 40), much flattened; half-anatropous (by analogy with other comparable seeds of Anacardiaceae), chalaza large and round, median on the concave margin (Pl. XIII, figs. 38–40), raphe not seen; micropyle beneath the truncate end of the endocarp; testa formed of a thin outer coat (seen only in section) and an inner coat of minute irregular polygonal cells which radiate from the chalaza, concentrically encircle the micropyle, and are longitudinally aligned at the opposite end. Length, about 5·3 mm.; breadth, about 2 mm.; dorsi-ventral thickness, 0·6 mm. (The length and breadth could not be measured very accurately as the seed was not completely freed from the endocarp, and in the absence of its endocarp a second isolated seed cannot be referred with certainty to this species.)

Remarks.—One endocarp from Herne Bay, also a detached seed from Sheppey which may belong to this species. As we could trace no indications of organs on the external surface of the endocarp, we at first thought it was a small piece of gnarled wood, so broke it to satisfy ourselves, thinking it was of no value. The fracture exposed the beautiful internal cast of the concave face of the seed with half of the clearly marked rim of the black chalaza. It also showed the transverse section of the seed, while a further fracture exposed the whole of its concave margin.

Affinities.—The woody gnarled endocarp with its flat sub-ovate form at once suggested a possible relationship with the following genera: *Helwingia* (Araliaceae), *Brucea* (Simarubaceae), *Ilex* (Aquifoliaceae), and *Odina* (Anacardiaceae). But closer study showed that alliance with all but *Odina* must be rejected, because in this genus alone the ridges of the gnarled and sculptured endocarp are formed of massive strands; in the other genera the ridges are formed of parenchyma, and the much more slender strands of fibres are merely carried along their crests; also the individual fibres which form the strands in *Odina* are slender as in the fossil; in the other genera they are coarse. In this genus also the seeds are arcuate, the shape conforming to a large tumidity on the locule over the chalaza of the seed, due to a thickening of the endocarp wall; but the arcuation, in some species at least, is more marked than in the fossil. The chalaza is similar and similarly placed, and the inner coat of the testa is alike in both. There need be no hesitation, therefore, in assigning the species to *Odina*. We have named it *Odina Jenkinsi* in honour of Mr. D. J. Jenkins the finder of the specimen. Many species of *Odina* have fruits which are comparable in size and form with the fossil. (Length of *O. wodier* Roxb., 8 to 11 mm.; breadth, dorsi-ventrally, 5·5 to 6·5 mm.; thickness, 4·5 mm. Length of *O. acida* A. Rich., 6·5 to 7 mm. Length of *O. humilis* Engler, 8 mm.) Although three or four locules may occur in the genus, often two or three are completely abortive, and the fruit then appears to be one-loculed like the fossil.

Odina is a large genus of small trees and shrubs which usually inhabit open situations, but occasionally form undershrubs in forests. They are chiefly inhabitants of tropical Africa, but also occur in the tropics of Asia. They may ascend to considerable altitudes (6,000 feet in Abyssinia).

V. 22556 Holotype, figured Pl. XIII, figs. 37–39. An endocarp, now fractured to show the character of the seed. *D. J. Jenkins Coll.*, Herne Bay.
V. 22557 Figured Pl. XIII, fig. 40. A seed, probably of this species. *Bowerbank Coll.*, Sheppey.

Odina europaea n. sp.

Plate XIV, figs. 1–4.

Diagnosis.—Endocarp sub-ovoid, two-loculed. Length, 6·6 mm.; greatest diameter, 5·6 mm.; least diameter, 4 mm. Seed curved.

Holotype.—V. 22558.

Description.—*Endocarp:* Sub-ovoid, syncarpous, with two one-seeded locules; locules as seen in median transverse sections either parallel to or inclined to one another, in the latter case the tumidities (see above, last species,) are on the exterior surface near the divergent ends, in the former case in corresponding positions; endocarp wall thick and woody, formed of large swirling strands of fine fibres which branch and anastomose so as to enclose interspaces filled with parenchyma; septum fibrous, a bundle of fibres entering from the exterior one-third of the length of the fruit from the base which, after breaking up and diverging transversely, reunite on the ventral margin to form a bundle which passes to the apical placenta; locule lined by clawed interlocking cells. Length, 6·6 mm.; greatest diameter, 5·6 mm.; least diameter, 4 mm.

Seed: Somewhat laterally compressed and arcuate in outline, the incurved margin facing the dorsal tumidity of the locule; anatropous, with the hilum adjacent to the apical placenta (by analogy with other similar seeds of Anacardiaceae), and the large circular chalaza rather below the middle of the concave face (Pl. XIV, fig. 2); testa formed (apparently) of an outer coat of polygonal cells (preserved only as impressions) and an inner coat (probably two or three cells thick) of minute equiaxial cells aligned in rows, the alignment of the successive layers being different so as to produce minute criss-cross striations, the cells of the innermost layer radiating from the chalaza.

Remarks.—Two specimens from Minster. One was nearly perfect showing well the exterior of the endocarp. This was fractured, and then showed the curved seed with its large chalaza turned to the exterior of the fruit, and the clawed interlocking cells lining the locule. The other specimen was much worn, the locule-casts being exposed at the apex of the endocarp. The two carpels were separated along the septum without much difficulty, showing its structure.

Affinities.—The form and structure of this two-loculed, one-seeded endocarp; the evidence for an apical placenta; the form of seed, position, and character of the chalaza and the structure of the testa, all indicate that the endocarp belongs to the Anacardiaceae. The characters are those of *Odina*, with the endocarps of which they are comparable in size. *O. fruticosa* Hochst. has fruits 5 to 7 mm. long and 6 mm. broad. In both this and other species, specimens with two locules occur. The distribution of the living *Odina* is given on p. 309.

V. 22558 Holotype, figured Pl. XIV, figs. 1–3. An endocarp, now fractured and partially dissected to show the seed and chalaza.

V. 22559 Figured Pl. XIV, fig. 4. Remains of an abraded and fractured endocarp, showing the seeds.
Both are Reid & Chandler Coll., Minster, 1929.

Odina (?) *subreniformis* n. sp.

Plate XIV, figs. 5–8.

Diagnosis.—Endocarp bean-shaped, one-loculed, one-seeded, the seed pendulous from the apex; hard and woody, formed of massive gnarled and twisted strands of fibres, which enclose lacunae filled with parenchyma. Length, 16 mm.; greatest diameter, 10 mm.; least diameter, 9·4 mm. Seed flattened, elongate with one straight and one slightly convex margin; half-anatropous, with terminal hilum, and chalaza at the middle of the straight margin. Length, 12 mm.; breadth, 4·5 mm.; thickness, 1·6 mm.

Holotype.—V. 22560.

Description.—*Endocarp:* Bean-shaped, one-loculed, one-seeded, the seed pendulous from the apex; hard and woody, formed of large gnarled and contorted strands of fibres having superficially a general longitudinal alignment although often sharply bent back and curved so as to enclose lacunae filled by parenchyma, within the thickness of the wall twisting in all directions but often perpendicular to the surface, the interspaces being filled with parenchyma; attachment terminal; from it a thick strand of fibres passes inward to form a broad longitudinal band within the thickness of the wall on the straight edge, whence it passes into the locule and is continued along this edge almost to the apex (probably quite to the apex, but it is here broken), where the placenta and hilum must lie, as we have traced the raphe in this part ; locule surrounded by a thick coat of cells now too decayed to be traced individually ; the actual lining formed of small interlocking digitate cells. Length of endocarp, 16 mm. ; breadth, 10 mm. ; thickness, 9·4 mm.

Seed: Flattened, elongate, with one straight and one slightly convex margin ; half-anatropous, with a thick raphe along the straight edge, hilum at or near the apex (shown by the raphe), and the broadly oval (or possibly reniform) chalaza at the middle of the straight edge but extending on to each face ; testa thin, too decayed to trace its cells, but obscure impressions on one side of the seed show that they radiated from the chalaza. Length of seed, 12 mm. ; breadth, 4·5 mm. ; thickness, 1·6 mm.

Remarks.—One fruit, which had fallen in two before it came into our hands. It showed the seed-cast lying in the locule, with remains of the testa adhering. The straight edge was covered by part of the endocarp which had broken irregularly ; therefore, in order to study the seed we decided to remove it from the endocarp. This exposed half of the chalaza on one side of the straight edge, a smooth oval area from which the cells radiated. Also the raphe was exposed on the same edge.

Affinities.—The structure of the carpel at once recalls the section Spondieae of the family Anacardiaceae. In this section are seen similar curiously contorted and gnarled strands of fibres embedded in parenchyma, and often enclosing spaces which are empty or filled with parenchymatous masses around which the fibres sweep. The structure of the seed and the arrangement of the different organs, so far as they can be traced, are also in keeping with such a relationship. Of those anacardiaceous fruits with which we have been able to make comparison, the fossil most resembles *Odina*, in which the same highly tortuous fibres occur, but it is larger than any species of that genus that we have seen. The fossil is comparable in size and outline with *Harpephyllum caffrum* Bernh. which, however, is cylindrical, not laterally compressed like the fossil, has less twisted and more longitudinally directed fibres, and more cavernous endocarp walls. We have, therefore, referred the fossil tentatively to the genus *Odina*.

V. 22560 Holotype, figured Pl. XIV, figs. 5–8. An endocarp with cast of seed. *Bowerbank Coll.*, Sheppey.

Genus XYLOCARYA nov.

Diagnosis.—Endocarp sub-ovoid ; syncarpous, three-loculed (one developed, two abortive) ; seed pendulous ; locules radially arranged, cylindrical ; outer coat of endocarp formed of parenchyma with interbedded fibres, locule lined by small polygonal cells. Length of endocarp, 10·25 mm. Seed cylindric, half-anatropous, with dorsal chalaza ; testa thin, formed externally of polygonal cells 0·012 mm. in diameter ; locule lined with cells 0·025 mm. in diameter longitudinally aligned. Length of seed, 9 mm.

Genotype.—*X. trilocularis* n. sp.

Xylocarya trilocularis n. sp.

PLATE XIV, figs. 9–12.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22561.

DESCRIPTION.—*Endocarp:* Sub-ovoid, somewhat compressed; syncarpous, three-loculed (with one developed and two abortive locules), the locules radially arranged (Pl. XIV, fig. 12), cylindrical (Pl. XIV, fig. 10); seeds pendulous; dehiscence probably by valves (subject discussed in the Remarks); walls thick, formed of an outer coat of fibres interspersed with, and lying upon, parenchyma which contains secreting cells represented by glistening globular bodies; on one face the fibres originate in a very thick basal strand which branches and anastomoses to form a conspicuous network (Pl. XIV, fig. 9) and on the other in a number of smaller basal strands which also form a network, but less conspicuous than the other (Pl. XIV, fig. 10); at the apex the coat is covered by a knuckle-shaped symmetrically placed cap of pyrites which probably has some structural significance, although what this is we do not know; the middle coat is formed of coarse horizontal fibres and within it is now a mass of pyrites with a few horizontal fibres preserved (probably the remains of a coat now perished); the locule is lined by small polygonal cells. Length (as preserved), 10·25 mm.; breadth, 7·3 mm.; thickness, 5·3 mm.

Seed: Cylindrical, half-anatropous, with a large, round black chalaza at the middle of the dorsal (external) surface; testa thin, formed externally of polygonal cells 0·012 mm. in diameter, and internally of polygonal cells 0·025 mm. in diameter, aligned in approximately longitudinal rows. Length of seed, 9 mm.; maximum breadth, 2·3 mm.

REMARKS.—One endocarp. The abortive locules are exposed throughout their length (Pl. XIV, figs. 10, 11) either by the abrasion of the carpel from their exterior faces, or because long valves have been shed from these faces, since the edges of the carpel are fairly smooth and finished. At the apex the two abortive locules narrow and curve inwards (Pl. XIV, fig. 11) evidently indicating that the funicles entered at these points to form the placentae. We were greatly puzzled by the specimen even after it was fractured transversely, and various interpretations were tried, based on the supposition that the abortive locules were merely lacunae in the carpel wall, filled with pyrites. But none of these would bring it into line with any known fruit. The possibility of the abortive locules being indeed locules, gave better promise, and this interpretation was later confirmed by the discovery of the chalaza, on a seed-cast in one of these locules.

AFFINITIES.—When this interpretation had been accepted relationship with the section Spondieae of the family Anacardiaceae was at once suggested, although we have found no genus that exactly agrees. But endocarps of similar shape are found in the section, and quite frequently some of the locules are abortive; the same structure of carpels and seeds is also common, the chalaza in the pendulous seeds being similarly placed and of similar character. But there is one essential difference if the fossil germinated by valves. Although the Spondieae germinate by throwing out dorsal plugs, they do not throw off long dorsal valves. It may be that these were merely plugs exaggerated in length, or it may be that they represent merely the results of abrasion and not plugs. We have, accordingly, whilst referring the specimen to the Spondieae, given it the new name *Xylocarya trilocularis*.

V. 22561 Holotype, figured Pl. XIV, figs. 9–12. An endocarp, now fractured transversely. *Bowerbank Coll.*, Sheppey.

Genus ? (ANACARDIACEAE, section Spondieae)

Plate XIV, figs. 13–15.

Description.—*Endocarp:* Sub-circular in outline, somewhat compressed, symmetrically two-lobed; syncarpous, three-loculed, with one developed and two undeveloped locules; the developed locule, which lies medianly between the lobes, is one-seeded, compressed parallel to the flattened faces of the lobes, arcuate, broad and truncate at the apical end, narrow and rounded at the opposite end (Pl. XIV, fig. 15); the abortive locules, which lie symmetrically one in each lobe near the surface, on that side to which the convex margin of the fertile locule is turned (by analogy with Spondieae the ventral margin), are embedded in a mass of pyrites which now constitutes almost the entire bulk of the lobes except immediately around the locules, the substance of the endocarp having perished (as evidenced by the symmetry of lobes which must indicate a former firm texture either of the lobes themselves or of their envelope, cf. preservation of *Hightea*, p. 442; and *Melicarya variabilis*, pp. 280, 281). Length of fruit, 4·6 mm.; breadth, 5 mm.

Seed: Compressed, arcuate, broader at one end than at the other, conforming in shape to the locule. Chalaza large, circular, median on the dorsal (concave) margin, hilum and raphe not seen. Testa formed of fine polygonal cells about 0·012 mm. in diameter; tegmen formed of thin-walled cells arranged in longitudinal rows which radiate from the chalaza. Length of seed, 4·5 mm.

Remarks.—One specimen, the external surface of which was much worn and polished, and gave little indication as to its nature. It was therefore fractured longitudinally along the groove delimiting the developed locule from one of the lobes, with the result that this locule and parts of the seed were exposed (Pl. XIV, fig. 15), but still the nature of the lobes remained unknown. One of these was therefore fractured transversely when the abortive locule and shrunken, distorted seed with its large chalaza came to view near the surface of the lobe.

Affinities.—The form of the developed seed, and the character of the integuments, both of it and of the abortive seed, also the character and position of the chalaza in the abortive seed, indicate quite clearly that the fruit belongs to the section Spondieae of the family Anacardiaceae. But the evidence is too incomplete for nearer determination.

V. 22562 Figured Pl. XIV, figs. 13–15. An endocarp, much abraded, now fractured. *Reid & Chandler Coll.*, Minster, 1929.

Family ANACARDIACEAE ?

Genus LOBATICARPUM nov.

DIAGNOSIS.—Endocarp sub-spheroidal, depressed, three- or four-lobed ; three- or four-loculed ; the locules radially arranged around a central axis, radially compressed, and bent so as to be concave dorsally and convex ventrally, their axes of curvature parallel with the axis of the fruit, but inclined to the long axes of the locules ; seed pendulous ; wall of endocarp with large globular cavities (floats) exterior to and partially embraced by the dorsal walls of the locules. Length, 10 to 12 mm. Seed similar in shape to the locules ; anatropous, with hilum near the apex of the locule, chalaza terminal at the opposite end, and raphe marginal.

GENOTYPE.—*L. variabile* n. sp.

Lobaticarpum variabile n. sp.

PLATE XIV, figs. 16–20 ; text-fig. 7.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22563.

DESCRIPTION.—*Fruit:* Sub-spheroidal, depressed, roundly three- or four-lobed, length three-quarters (or less) of breadth ; syncarpous, three- or four-loculed, the locules being symmetrically placed around a central axis, whilst external to them, lying on the same radii, and partly embraced by their dorsal walls, are globular cavities (Pl. XIV, figs. 18, 19 ; text-fig. 7) ; above the axis at the apex is the stylar scar, a raised ring, in the middle of a small circular depression (Pl. XIV, fig. 20), which tends to come away as a little cap ; seeds pendulous, solitary in the locules ; locules triangularly sub-ovate in outline, with a flattened inverted funnel-shaped latero-apical prolongation where the funicle enters (Pl. XIV, figs. 16, 17), in transverse section radially compressed, bent so as to be concave dorsally (towards the cavities) and convex ventrally, the axis of curvature not coinciding with the long axis of the locule, but parallel to the axis of the fruit, so that the long axis of the locule makes an acute angle with the axis of the fruit ; dehiscence by valves, the large dorsal valves comprising the entire dorsal wall including the large globular cavities (text-fig. 7) ; pericarp (as preserved ; partially carbonized) formed of an outer coat of parenchyma within which are embedded numerous longitudinal strands of fibres as long as the fruit ; other strands cover the surface, pass between the lobes, and lie along their median lines, these latter branching, and ultimately breaking up

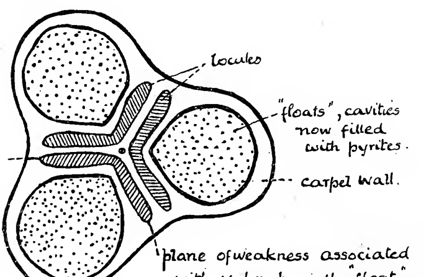


FIG. 7.—Diagrammatic transverse section of fruit of *Lobaticarpum*.

into delicate threads; within this fibrous coat is one of parenchyma the cells of which are from 0·025 to 0·05 mm. in diameter; the locules are lined by digitate interlocking cells (but rarely to be seen) which vary in size in different parts, ranging from 0·016 to 0·025 mm. in diameter. Length of fruit, 10 to 12 mm.; radius from the axis to the exterior of the lobes, 9 to 12 mm.

Seed: Obovate, radially compressed, conforming to the locule in shape and curvature, so that the axis of curvature and the long axis of the seed do not coincide; anatropous, with hilum near the apex of the locule, chalaza terminal at the opposite end (showing as a small mucro on the seed-cast, around which the cells are concentrically arranged), and raphe on one of the margins (seen on the seed-cast as the impression of a narrow strand of fibres; internal surface of testa formed of irregular, often sharply angled polygonal cells (measuring 0·032 to 0·05 mm. in diameter), which have thin lateral walls and tend to be transversely aligned. Length of seed from hilum to chalaza, 5 mm.; breadth, 3·75 mm.

Remarks.—Fourteen fruits and two isolated globular bodies (casts of cavities). The fruits present the greatest diversity in appearance according to the number of locules, the degree of development of the globular cavities, and the degree of abrasion which they have undergone. On two only have the external fibres been preserved. The globular cavities, which probably constituted floats for buoying up the fruits in water, are now almost invariably filled with pyrites and often the pericarp is completely worn away over their hard resistant surfaces (Pl. XIV, fig. 20); or abrasion may even be carried a stage further: the casts of these "floats" may break away completely and, as we have seen, be found as isolated bodies. In such specimens the dorsal walls of the locules are then laid bare and these are easily removed as valves exposing the locules themselves or the locule-casts, also easily removable and sometimes enclosing seed-casts which show the form and anatomy of the seeds. Specimens which have lost their floats are therefore three-rayed, the re-entrant angles between the rays corresponding to the former position of the floats.

Affinities.—The important diagnostic features of this fruit are that it is syncarpous, with three or four one-seeded locules, axile placentation, pendulous anatropous seeds, and dorsal germination valves. The only family we can discover which combines these characteristics is the Anacardiaceae. In many genera of the section Spondieae the endocarps are cavernous, and in *Allospondias* Stapf, one large cavity is associated with each locule, although, in this case, cavities and locules are arranged on alternate radii. Many genera, too, have the locules lined with digitate interlocking cells.

Against the ascription of the fossil to Anacardiaceae is the position of locules and cavities on the same radii, the apparent lateral position of the raphe, and the large size of the germination valves. We can, however, suggest no more likely relationship and have therefore referred the fruits doubtfully to the family, but in view of their distinctive characteristics, and of the completeness with which the details of their structure are known, we have given a new generic name *Lobaticarpum*.

V. 22563 Holotype, figured Pl. XIV, fig. 16. A fruit, showing the pendulous seed (locule-cast) and the floats represented by masses of structureless pyrites.

V. 22564 Figured Pl. XIV, fig. 17. A fruit, showing the anatropous seed with the chalaza clearly marked. The locule-cast is largely chipped away.

V. 22565 Figured Pl. XIV, figs. 18, 19. A three-loculed fruit, somewhat abraded, so as to show the arrangement of the locules and floats with regard to the axis and to one another.

V. 22566 Figured Pl. XIV, fig. 20. A fruit, much abraded so that the casts of the three floats are more or less completely exposed. Now fractured.

V. 22567 A well-preserved fruit, from which the floats and the valves of the locules have broken away, displaying the locule-casts and placentation.

V. 22568 A fruit, dissected to show the locule-casts, valves of the locules, floats, and a seed-cast with chalaza.

V. 22569 A fruit, abraded to show pyrites filling the float in one carpel; the carpel wall is preserved in the others.

V. 22570–72 Three fruits. Each is in fragments.

V. 22573 Three abraded fruits (one in pieces), and the pyrites casts of two floats belonging to other fruits.

The above are all from the Bowerbank Coll., Sheppey.

V. 22574 A worn fruit. *Reid & Chandler Coll.*, Minster, 1929.

Genus ? (ANACARDIACEAE ?)

Plate XIV, figs. 21, 22.

Description.—*Fruit:* Approximately almond-shaped with a slight asymmetrical concavity near the middle of one face; attachment and style at opposite ends, the former marked by a small circular scar, the latter by the radiating cells of the pericarp; near the style is a small black scar (seen on the cast where the pericarp has been chipped away) which may represent either the placenta on the face of the locule, or one of the organs of the seed; the locule (as shown by a longitudinal break) is concavo-convex, the concavity being under the slight concavity of the nut (Pl. XIV, fig. 22); pericarp smooth externally (rather worn and obscured by pyrites) formed of an outer coat of polygonal cells (about 0·1 mm. in diameter) containing some kind of secretion, in the thickness of which is embedded a system of coarse branching and anastomosing fibres which arise from the base; and an inner coat formed of a single layer of close-set polygonal cells about 0·05 mm. in diameter containing a black secretion; along one margin this coat forms an infold or canal which is filled in, and covered by, the outer coat so that no sign of it appears on the surface; similarly the coat follows the concave face of the locule, the concavity, again, being almost obliterated by a thickening of the outer coat; the innermost coat (whether belonging to carpel or seed we do not know) is formed of small cells obliquely aligned. Length of nut, 11 mm.; breadth, 6 mm.; thickness, 3·5 mm.

Remarks.—One specimen from Herne Bay. It showed no external features which would permit of diagnosis, and we did not at first feel sure whether it was a fruit or merely a piece of wood. It was therefore fractured transversely, whereupon it also broke longitudinally in the upper part.

The longitudinal furrow along the thicker edge of the nut, filled as it is by tissue belonging to the outer layers of the carpel, may perhaps be the funicular canal, in which case the seed is pendulous from the apex and the organ adjacent to the style either the hilum or placenta. Again, the lateral depression may be associated with the chalaza, or, on the other hand, it may merely be the effect of shrinkage, as may be also the marginal groove, the pericarp having been better preserved in these hollows than elsewhere on the surface. We have no clue as to which is the right interpretation.

Affinities.—The character of the highly resinous (or oily) wall, the form of the fruit and arrangement of its organs so far as these have been traced, suggest that the specimen should be referred to the family Anacardiaceae (not the section Spondieae). A lateral chalaza (if the lateral depression really is associated with a chalaza) would lend support to this view. Against the ascription to Anacardiaceae is the fact that we have not been able to find an exactly comparable succession of coats in any living fruits and seeds belonging to the family. We can suggest no other relationship, however, and have therefore referred the specimen doubtfully to the Anacardiaceae.

V. 22575 Figured Pl. XIV, figs. 21, 22. A fruit, now fractured. *D. J. Jenkins Coll.*, Herne Bay, 1929.

Family CELASTRACEAE

Genus CATHISPERMUM nov.

Diagnosis.—Fruit sub-ovoid, obscurely five-lobed at one end; syncarpous, five- (or ten- ?) loculed, the locules arranged irregularly around an axis, and with about ten seeds. Length, 7 mm. Seeds sub-ovoid, slightly compressed, winged (or arillate ?) at the hilar end, flanged and spiny along one margin; anatropous, with hilum and chalaza at opposite ends, the hilum lying beneath the aril, and raphe beneath the flange or on one of the flattened faces; testa with an outer layer of conspicuous, much inflated cells from 0·05 to 0·1 mm. in diameter, which give a tubercled surface. Length of seed, about 3 mm. without aril; 5·8 mm. with aril.

Genotype.—*C. pulchrum* n. sp.

Cathispermum pulchrum n. sp.

Plate XIV, figs. 23–28.

Diagnosis.—That of the genus.

Holotype.—V. 22576.

Description.—*Fruit:* Sub-ovoid, obscurely five-lobed at the end to which the hilum of the seed is turned, but not at the other to which the chalaza is turned, the lobes dying out near the middle (Pl. XIV, fig. 23); syncarpous, with five (or ten ?) locules and numerous seeds (ten ?) irregularly arranged around an axis, if five-loculed then probably with two seeds in each locule (some perhaps abortive), if ten-loculed then probably with one seed in each locule, seeds and locules much displaced, but each seed lies in a cavity (locule ?) lined with transverse fibres; at the unlobed end is a ring of ten (?) small apertures (eight actually seen, but symmetry suggests ten) which are the openings of narrow canals leading into the locules;

pericarp and septa fibrous, one strand lying medianly along each lobe, and the septa being formed by layers of fibres with variable alignment, mostly oblique, which often produce criss-cross impressions, the fibres forming the layer lining the locules arise obliquely from the axis and then become transverse. Length, 7 mm.; diameter, 3·5 mm.

Seed: Elongate, sub-ovoid, being rounded at the hilar end, obtusely pointed at the chalazal end, and slightly compressed, with one margin more convex than the other, the convex margin being flanged and the flange bearing curved spines about 0·1 mm. long (obscurely seen Pl. XIV, fig. 28), at the hilar end asymmetrically attached to the flange, is a thin wing-like prolongation (arillus ?) which obscures the hilum (Pl. XIV, figs. 26–28); anatropous, with chalaza forming a small cap at the narrow end, raphe either underlying the flange or on one of the flat faces, hilum not actually seen, but evidently beneath the arillus since the raphe has been traced so far; micropyle adjacent to the hilum (appearing on the seed-cast as a small circular depression, seen in profile, Pl. XIV, fig. 26); testa formed over the seed-body of three coats, an outer very conspicuous and characteristic coat greatly thickened over the flanged margin, sometimes 0·125 mm. thick, formed of a single layer of large cells with double walls (from 0·05 to 0·1 mm. in diameter) usually polygonal or hexagonal in surface view, and much inflated so that their impressions produce pitted surfaces both on outside and inside casts of the seed; within this coat is a finely striate one formed by narrow elongate cells aligned longitudinally; the innermost coat (tegmen ?) is formed of small polygonal cells 0·025 to 0·05 mm. in diameter, which tend to be transversely aligned; the surface of the wing or arillus is covered by very irregularly shaped and irregularly oriented fusiform or polygonal cells with an average breadth of about 0·05 mm., which diverge from the hilum and to some extent from the raphe; within this coat is a striate layer formed of elongate cells as in the testa (an intervening space between the two surfaces of the wings is now filled by structureless pyrites). Length of seed body exclusive of wing, 3 mm.; greatest diameter, 1·5 mm.; least diameter, 1 mm.; approximate length with wing, 5·8 mm.

REMARKS.—Two fruits. The one taken as the holotype was in a decaying condition, and so much worn that the seeds were exposed at the surface. Before it could be photographed as a whole it fell to pieces, but some of the seeds with their arils are preserved and have been figured (Pl. XIV, figs. 26–28). The second fruit (V. 22577) showed more of the carpel with its longitudinal rounded ribs and the small apertures at the opposite extremity. It was pieced together so that it could be figured (Pl. XIV, fig. 23; cf. also figs. 24, 25), but is now represented by small fragments and detached seeds which have lost the aril, always obscure in this specimen.

We at first found the interpretation of this species extremely difficult, because either as the result of natural development, or of compression and distortion during fossilization, the locules appeared to be so irregularly placed that their relationship to one another and to the symmetry of the fruit could not be satisfactorily determined. In the holotype (V. 22576) six developed seeds, and one undeveloped, were found, apparently arranged more or less symmetrically around the axis. The second specimen (V. 22577) showed a larger number of seeds (ten ?), not all lying at the same level. In every case the seeds appear to have lain within separate cavities with fibrous walls, the innermost layer being formed of transverse fibres. Experience has led us to recognize that such structures usually belong to the pericarp, the transverse fibres representing the locule-lining. We may therefore infer that the fruit was syncarpous and multilocular, although we cannot definitely ascertain the number of locules. But the five-lobed form, the arrangement of the terminal canals, and the number of seeds, appear to indicate either a five-loculed fruit with two-seeded locules, the locules being separated by false partitions, or a ten-loculed fruit with one-seeded locules, some of the seeds being abortive. We cannot tell with certainty which end of the fruit is the base and which the apex. The aril in the fossil seeds is clearly thin and fragile and is readily detached from the seed body. Hence it is not surprising that it is often torn, and sometimes not visible at all. Between the two surfaces of the aril there was evidently a cavity which may or may not originally have been occupied by thin tissue, but now, as the result of fossilization, is filled with pyrites.

Affinities.—The fossil seed is exactly comparable in character with the seeds of *Catha edulis* Forsk. These are of identical form, have very similar wing-like arils arising asymmetrically from the hilum so as to lie towards one side of the seed; the cell structure also, both of testa and aril, is almost identical, the same succession of coats appearing in both. In the living *Catha* the seeds are erect, attached near the middle of the locules, the bases of which are occupied by the arils. Nevertheless the number of locules in *Catha* is only three, whereas in the fossil it was at the least five. If we possessed the full evidence in regard to the fossil fruit we might have been able to trace more closely its relation to *Catha*, and so to discover if once again in this species we had evidence of the suppression of locules with the lapse of time. Certainly on the evidence, as it stands, we cannot regard the fossil as generically identical with *Catha*, although it would undoubtedly appear to be its nearest living ally. We have named it *Cathispermum pulchrum* to indicate this relationship.

The genus *Catha* is monotypic and is indigenous to Arabia, and to Africa from Abyssinia to the Cape.

V. 22576 Holotype, figured Pl. XIV, figs. 26–28. Several seeds, originally enclosed in a decaying fruit. This has now disintegrated and the seeds have fallen free. Internal cast of a seed with wing preserved (fig. 28). A seed with testa preserved (fig. 27). A seed body with part of the wing still adhering; the micropylar scar is at the apex where the wing has been partly broken away (fig. 26). *Bowerbank Coll.*, Sheppey.

V. 22577 Figured Pl. XIV, figs. 23–25. A broken fruit now in a fragmentary condition. It was pieced together as far as possible and figured to show the form; fragments were also figured to show the seeds (broken) lying in the fruit. *Bowerbank Coll.*, Sheppey.

Genus CANTICARPUM nov.

Diagnosis.—Fruit sub-globular with three two-seeded locules (or perhaps one six-seeded locule through incompletion of the septa); pericarp fibrous, the fibres diverging obliquely from short (apical ?) median ribs on each carpel, but becoming horizontal. Length, 6 mm. +. Seed ovoid, narrowed at the micropylar end, rounded at the chalazal end; testa everywhere formed of three coats, and in parts (everywhere ?) covered by a layer of thin-walled polygonal cells (0·036 to 0·05 mm. in diameter); when this is absent the surface is tubercled.

GENOTYPE.—*C. celastroides* n. sp.

Canticarpum celastroides n. sp.

PLATE XIV, figs. 29–33.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22578.

DESCRIPTION.—*Fruit:* Sub-globular, but slightly three-lobed; syncarpous, with three carpels and three two-seeded locules, one in each lobe, one of the locules being abortive and containing two abortive seeds (or possibly one-loculed by part suppression of the septa, which cannot be traced to the middle of the fruit); seeds attached at one end (apex ?) of the fruit, from which three strands of fibres diverge; no axis has been seen (but it may have decayed as sometimes happens in London Clay fruits); pericarp (as preserved) formed of layers of fibres which diverge obliquely from the three strands above referred to; the strands lie medianly over the dorsal face of each carpel, are about one-third as long as the fruit, and where they end the fibres of the pericarp fan out from their extremities and become horizontal like the others. Such a structure strongly suggests loculicidal dehiscence at the apex of the fruit, but we have no proof that this occurred. There is, however, evidence of septicidal splitting, for a film of pyrites has penetrated along a plane of separation in the middle of two of the septa as seen in section. The fibres lining the locule are more slender than those of the outer layers, are very long and taper at their ends, and the surface they form is smooth and shining. Length (slightly reduced by abrasion), 6 mm.; approximate diameter, 6 mm.

Seed: Obovoid, narrowed at one end, rounded at the other; probably anatropous, the chalaza a circular or oval scar, about 0·8 mm. in diameter, being at the rounded end; the raphe probably coinciding in position with a ventral ridge, and the hilum being probably adjacent to the micropyle which is marked by a small apiculation at the narrow end of the seed; testa certainly formed of three coats and in parts (doubtful whether over the whole) covered by a fourth outer coat (perhaps an aril) formed of thin-walled polygonal cells 0·036 to 0·05 mm. in diameter; the outer of the three coats is formed of a single layer of regular polygonal or hexagonal thick-walled cells (0·05 mm. in diameter) inflated at their outer ends so that where they form the surface it is closely and flatly tubercled (Pl. XIV, fig. 32); the middle of the three separated from the last by a film of pyrites is a coat columnar in section and not less than 0·05 mm. thick, formed of polygonal cells 0·02 to 0·025 mm. in diameter, which on the outer and inner surfaces of the coat are longitudinally aligned but converge to the micropyle (in fossilization this coat often partially decays and appears longitudinally striate) (Pl. XIV, fig. 33); the innermost coat is formed of flat, thin-walled angular cells of irregular shape 0·025 to 0·05 mm. in diameter. Length, 3·25 mm.; breadth, about 2·35 mm.

Remarks.—One specimen, considerably distorted, being compressed obliquely from top to bottom so that one of the fertile locules was crushed down upon the other, and the surface was much battered and worn so that the lobing scarcely showed except at the apex (Pl. XIV, fig. 29), and the only striking feature was the divergence and fanning out of the fibres from the longitudinal strands. We fractured it in order to discover its structure, and then saw two seeds in one locule, one on each side of the fibrous strand, two other seeds being also partly shown in the adjoining locule. The testa was clearly shown (Pl. XIV, fig. 32), but the seed organs were not. We therefore removed the locule-casts and pericarp from over some of the seeds, with the result that the micropyles of two adjacent seeds, but in different locules, were found lying close together at the narrow ends of the seeds. Probably, therefore, the hilums were also close together at the same ends, but they were not visible. The decayed columnar coat of the testa was clearly seen. We next freed one of the seeds from the locule and removed the testa from its rounded end, thereby exposing the large scar of the inner chalaza.

Affinities.—We have compared this fruit and its seeds, so far as possible, with all the three-carpelled syncarpous fruits known to us, whether these were one- or three-loculed, because the evidence as to the continuation of the septa to form three complete locules is inconclusive. The only family in which we have found fruits of comparable size and shape with fibrous carpels of similar structure, and with seeds comparable in size, shape, and cell-structure, is the Celastraceae. In this family the three carpels are united by the septa, and in every case, when the fruit is dehiscent, dehiscence is initially loculicidal ; but even so the contiguous faces of the septa are readily separable and then show finished surfaces along the planes of separation. The seeds of *Celastrus* are similar in size and shape to those of the fossil, and throughout the family, in the limited number of genera which we have been able to study in detail, the same succession of coats occurs : first an aril (in many but not in all genera), next a coat formed of a single layer of large polygonal cells, next a columnar coat longitudinally striate on both its surfaces which may be thick as in *Maytenus* Molina, or thin and soft as in *Celastrus* Linn. (In *Gymnosporia* Benth. et Hook. f. this coat is associated with an inner layer of transversely aligned cells) ; the innermost layer, the tegmen, is formed of large polygonal cells. It is evident that the resemblances to Celastraceae are very striking, but the fossil is imperfect, so that our knowledge of it is incomplete. The cells of the columnar coat in those seeds of Celastraceae which we have seen are larger and not so accurately aligned in longitudinal rows. While, therefore, we refer it to the family we cannot relate it to any living genus that we know, so have given it the name *Canticarpum celastroides*.

V. 22578 Holotype, figured Pl. XIV, figs. 29–33. A fruit now fractured to expose the seeds. A detached seed (V. 22578*a*) is illustrated in fig. 33 ; a second detached seed (V. 22578*b*) shows the chalaza very clearly. *Reid & Chandler Coll.*, Minster, 1929.

Family ICACINACEAE

The Icacinaceae are represented by no less than six genera and at least nineteen species, individual species being present, in many cases, in great abundance, so that the family must have formed a very important element in the London Clay flora.

In many specimens the endocarp is preserved, but as a rule it is much abraded, and often it is only the locule-cast which remains, with fragments or thin films of the endocarp adhering. When the characters of species are distinctive and conspicuous, it has been easy to sort the specimens into groups ; but, owing partly to the natural similarity of some species, partly to variation in appearance consequent on the state of preservation, and partly to the fact that many distinguishing characters can only be observed under the microscope, it has been a laborious and difficult task to discriminate between the less well-marked species. In some cases it has been necessary to dissect or fracture specimens before the evidence for inclusion in a given species, or even in the family, could be found.

Ettingshausen did not recognize the family, and many of the specimens which, after dissection and study, we have been able to refer to it, were labelled by him as belonging to other families.

At the present time the Icacinaceae are entirely tropical. The family consists of trees, shrubs and, rarely, of herbaceous plants ; the shrubs being for the most part climbers. The endocarps as a whole form a very homogeneous series, so that they are readily recognizable by their anatomical characters. They are two-valved, one-loculed, with one developed seed. All are bisymmetric and woody, and are frequently formed, in part at least, of interlocking digitate cells. The funicle enters the endocarp at the base and lies in a conspicuous canal which passes within the thickness of the wall, along one of the lateral margins, to the apex. At the apex it turns sharply into the locule, where it forms the apical placenta. The course of the funicular canal and the position of the placenta furnish amongst other characters, such as the cell-structure of seed and endocarp, some of the best means of distinguishing between the stones of Icacinaceae and Prunoideae. In the latter the funicle also lies within the lateral margin of the endocarp, but passes obliquely through its thickness, entering the locule sub-apically and without any abrupt turn inwards. The placenta is, therefore, sub-apical. In the Icacinaceae the style is always apical and the stylar canal is a fairly conspicuous duct in close proximity to the placenta. The fruits are very variable in size, but a general uniformity of arrangement and structure persists in all. The seed is highly characteristic. It is anatropous, the hilum and micropyle being adjacent to one another at one end, and the chalaza near the other end, the raphe lying nearly medianly on one of the flat faces. The hilum and chalaza, and sometimes the micropyle also, are conspicuous circular organs from which the cells of the testa radiate. The micropyle lies close beneath the style. The testa is usually formed of small inflated quadrangular or square cells.

Endocarps belonging to the Icacinaceae have previously been recorded from the upper Eocene beds of Hordle, Hants. They were referred to the genera *Natsiatum* and *Iodes* (Chandler, 1925, p. 29, pl. iv, figs. *7a–d*, 10).

Section *Iodeae* Engler

Genus IODES Blume

1825. Bijdr. Fl. Ned. Ind., p. 29.

Iodes corniculata n. sp.

Plate XIV, figs. 34–43.

1840. ? *Leguminosites elegans* Bowerbank (pars), p. 126, pl. xvii, fig. 6.

Diagnosis.—Endocarp broadly oval, or ovate, lenticular in transverse section, ornamented with fifteen to twenty shallow concave areas separated by ridges, with a tendency to be arranged in four longitudinal rows. Style flanked by a horn-like projection on each lateral face; locule-lining papillate. Length, 8 to 9 mm.; breadth, 5·5 to 7 mm.; thickness, 4 mm. Seed: testa cells, 0·025 mm. in diameter.

Holotype.—V. 22579.

Description.—*Endocarp:* Bisymmetric, broadly oval or ovate, lenticular in transverse section, usually narrowed at the apex and rounded at the base, splitting along the margin into symmetrical halves; exterior boldly ornamented with fifteen to twenty shallow concave areas separated by rounded ridges, which have a marked tendency to be arranged in four longitudinal rows. A strong rounded rib on one of the lateral margins indicates the position of the funicle, which runs from base to apex of the endocarp in the thickness of the wall beneath this rib (Pl. XIV, fig. 35).

Style apical, flanked on each broad face by a small horn-like projection pierced by a canal (Pl. XIV, figs. 34–36). Endocarp wall thick and woody, formed of a mass of large cells with interlocking digitations, the cells near the locule being about 0·03 mm. in diameter. Locule-lining bearing closely set papillae which give rise to punctations on the pyritized locule-casts, there being three or four such papillae in 0·25 square mm. The papillae are separated from one another by a space approximately equal to their own diameter. Placenta apical, adjacent to the internal opening of the style. Length of endocarp, 8 to 9 mm.; breadth, 5·5 to 7 mm.; thickness, 4 mm.

Seed: Solitary, conforming in shape to the locule, pendulous, anatropous; hilum a circular scar with well-defined rim, 0·04 mm. in diameter, lying in a depressed area at the base of the seed (the end turned to the apex of the locule), micropyle adjacent to the hilum at the edge of the depressed area, raphe traversing one of the flat faces, usually lying within a median longitudinal groove which shows the impression of fibres (Pl. XIV, figs. 42, 43); chalaza a conspicuous circular scar at the extremity of the seed opposite to the hilum, about 0·05 mm. in diameter. Testa formed of inflated angular cells which radiate from the chalaza and the hilar-micropylar region. The average size of these cells is about 0·025 mm. Length of typical seed, 4·5 mm.; breadth, 4·3 mm.

Remarks.—The species is represented by sixty-three nuts from Sheppey which show diversity of size and appearance according to the degree of abrasion of the endocarp, which is always more or less carbonaceous. A specimen was also recently found at Herne Bay. In some specimens (Pl. XIV, fig. 37) the outer layers of the endocarp are preserved in the concave areas but are worn away over the ribs ; in such specimens the sculpture is very bold. More frequently only the inner layers are preserved, and these alone may be as much as 0·5 mm. thick, but have usually been abraded so as to be very thin. In such specimens the surface is much less highly sculptured, the marginal rims are less marked, the funicle being usually worn away except at the apex where it may remain encased in a knob of structureless pyrites (Pl. XIV, figs. 38–40). The horn-like apical projections are also frequently worn away. When by further abrasion the inner carbonized layer has been removed the locule-cast alone remains. Its outer surface is pitted, the pits being the impression of papillae on the locule-lining, as can be verified when they are seen in section. Occasionally a few large irregularly scattered mammillations can be seen on the locule-cast. These have no structural significance, and are probably due to bubbles of gas formed during fossilization. Within the locule-cast may lie the seed, or the seed-cast (Pl. XIV, figs. 41–43). Occasionally the papillae of the locule-lining have impressed themselves on to the testa, but more often the seed is somewhat shrunk and crumpled.

Crow drew a specimen of *Iodes corniculata* in his manuscript catalogue (1810, No. 695). Further, it is not impossible that *Leguminosites elegans* Bowerbank (pars, 1840, p. 126, pl. xvii, fig. 6) and this species, are identical. But the identity cannot be definitely established, and Bowerbank's specimen is described below as *Icacinicarya elegans* (see p. 353).

Affinities.—The ornamentation of the surface, the apical horn-like canals, the funicle, placenta, testa, raphe and chalaza in the fossil are characteristic of the family Icacinaceae and of the section Iodeae Engler. Although in form and sculpture it compares closely with specimens of *Natsiatum sinense* Oliver, yet in *Natsiatum* the locule-lining is not papillate. This character is found in species of *Iodes* which we have examined. By a careful study of macerated fragments of *Iodes africana* Welw. ex Oliver we were able to observe structures closely comparable with those described above. Some of them were not apparent prior to maceration with nitric acid. After chemical treatment we found that the pericarp consisted of exocarp and endocarp separated by a network of fibres ; it is the endocarp only which is preserved in the fossils, the exocarp and fibres having perished. The endocarp of the living species is close textured and bony, the lining being formed of cells each with a rounded papilla projecting into the locule, as in the fossil. The external part of the endocarp is formed of a mass of softer tissue which may be shredded into several layers. After maceration, all layers present a rough surface formed of digitate cells, although individual cells are somewhat difficult to distinguish. The testa cells of the living species are smaller than those of the fossil, but are otherwise identical in character. The scars of the micropyle and chalaza are also identical in the two both in form and position, and the raphe is similar and similarly placed on one of the flattened faces.

Although the fossil endocarps are small, less than half the size of those of

I. ovalis Blume (length 13 mm.), and about half the size of those of *I. africana* (length 10·5 mm.), the evidence points definitely to a close relationship to the genus *Iodes*. The difference in size is not sufficient to debar the fossils from inclusion in the living genus, for the living *I. ovalis* is itself less than half the size of the living *I. reticulata* Stapf. Further, in *I. ovalis* the concave areas on the external surface show a marked tendency to be arranged in four longitudinal rows as in the fossil.

Iodes is a genus of climbers inhabiting China, Burma, Indo-China, the Malay Peninsula and Islands, the Philippines, tropical Africa, and Madagascar. *I. ovalis* is a native of south-eastern Asia from Java to New Guinea and the Philippines.

V. 22579 Holotype, figured Pl. XIV, figs. 34–36. An endocarp, showing very clearly the "horns" (pyrites casts of short canals) near the style, also the canal for the funicle.

V. 22580 Figured Pl. XIV, fig. 37. An endocarp, showing how the outer layers peel away leaving the more heavily pyritized inner layers.

V. 22581–83. Figured Pl. XIV, figs. 38–40. Three specimens, showing successive stages in abrasion. In V. 22581 much of the carpel wall remains. In V. 22582 much has been removed revealing the internal cast of the locule with the pyrites knob representing the placenta (cast of the inner end of the fibro-vascular canal, fig. 39). In V. 22583 the cast is exposed completely save for a thin film of endocarp wall still clinging in the hollows. The knob representing the placenta is seen projecting near the apex (fig. 40).

V. 22584 Figured Pl. XIV, fig. 41. An internal cast of an endocarp which has been largely chipped away, except at the apex, showing the cast of the seed lying within.

V. 22585 Figured Pl. XIV, figs. 42, 43. A seed, internal cast, completely freed from the endocarp and locule-cast. It shows the raphe, hilum, and micropyle. It also shows the chalaza, but this is not visible in the figure.

V. 22586 Three very well-preserved fruits, showing the "horns" at the apex.

V. 22587 Forty fruits in various stages of abrasion; some show the endocarp wall, many are internal casts of the endocarp with a film only of the wall adhering. A few show traces of the seed.
All the above are from the Bowerbank Coll., Sheppey. They were labelled by Ettingshausen "*Carpolithes* sp. nov.", together with many specimens of *Iodes multireticulata*.

V. 22588 Thirteen endocarps, usually much abraded. *Reid & Chandler Coll.*, Minster, 1928, 1929.

Iodes multireticulata n. sp.

Plate XV, figs. 1–11.

1879. ? *Sapotacites Mimusops* Ettingshausen (pars), p. 394.
1879. ? *Sapotacites chrysophylloides* Ettingshausen, p. 394.
1879. ? *Leguminosites crassus* Bowerbank: Ettingshausen (pars), p. 396.

Diagnosis.—Endocarp oval or ovate, slightly narrowed at the apex, lenticular in transverse section, surface with thirty to fifty concave areas irregularly arranged; locule-lining minutely papillate. Length, 8 to 12·5 mm.; breadth, 4 to 7·5 mm.; thickness, 3·4 mm. Seed with testa cells, 0·025 mm. in diameter.

Holotype.—V. 22589.

Description.—*Endocarp:* Bisymmetric, broadly or narrowly ovate or oval, lenticular in transverse section, rounded at the base, often slightly narrowed or pointed at the apex, splitting along the margin into symmetrical halves. Exterior conspicuously ornamented with thirty to fifty shallow concave areas separated by low rounded ridges having no definite arrangement except that a few of the stronger ribs have an irregular longitudinal alignment, while several small oblique or transverse ribs diverge from the thickened lateral margin which carried the funicle. Style apical, with a canal which opens externally by a transversely elongate aperture (Pl XV, fig. 3). The funicle enters the endocarp at the base and passes in its thickness to the apex, where it bends sharply inwards to the apical placenta. Endocarp wall thick, formed, at least in part, of equiaxial, digitate cells 0·016 mm. in diameter. Locule-lining formed of flat, closely-interlocking digitate cells, each about 0·2 mm. in diameter and each bearing a minute papilla at its centre ; thus the locule-lining is minutely and regularly papillate, the papillae (about 0·05 mm. in diameter) being larger, further apart and more regularly spaced than in *I. corniculata* (p. 323). Length of endocarp, 8 to 12·5 mm. ; breadth, 4 to 7·5 mm. ; thickness, 3·4 mm.

Seed: Solitary, pendulous from the apex, anatropous, when fully developed filling the locule. Hilum circular with well-defined rim, marginal, terminal, lying close beneath the placenta ; raphe a flat longitudinal band of fibres, sometimes sunk in one of the flat faces (Pl. XV, fig. 8) ; chalaza at the opposite end to the hilum (Pl. XV, fig. 8) ; micropyle terminal, close to the hilum. Testa formed of large square, quadrilateral or rhomboidal cells, which are convex towards the exterior and concave towards the interior. They are about 0·025 mm. in diameter. At the two ends of the seed they radiate from the hilum and chalaza respectively.

Remarks.—The species is abundant at Sheppey, and also occurs at Herne Bay. There are over 100 undoubted specimens and several more that are doubtful. The endocarp is usually much abraded, but in some specimens it is preserved (Pl. XV, fig. 1). The locule-cast is frequently well-preserved, the small pits formed by the papillae being very conspicuous (Pl. XV, fig. 7). When seen in section the papillae are short with their free ends swollen. Very rarely the lining layer of the endocarp is sufficiently well-preserved to show its surface beset with the minute protuberances. When the interspace between the endocarp and seed is filled by a shell of pyrites (the locule-cast) the inner surface of this shell in contact with the seed may bear the impression of the outer cells of the testa, just as the inner surface of the testa may be impressed upon the seed-cast within it. In many specimens the seed has shrunk prior to fossilization and then usually occupies an asymmetric position within the locule-cast.

An aberrant specimen of this species was bilobed longitudinally so that it had the appearance of two accrescent carpels (Pl. XV, figs. 10, 11), but on fracturing the specimen along the apparent junction there was no evidence of an intervening carpel wall. The peculiar form may perhaps be due to the abnormal development of two ovules which are present in the ovary of icacinaceous fruits, although only one develops. In this specimen the seed or seeds were not preserved, consequently we cannot test the accuracy of the surmise. The remains of the inner end of the funicle still adhering to the cast forms a small projection at the apex (Pl. XV, fig. 11). It formerly lay symmetrically along the convex margin where the lobes meet (the margin seen in profile at the base of Pl. XV, fig. 10).

Affinities.—The structure of endocarp and seed place this species beyond doubt among the Icacinaceae and in the section Iodeae of Engler. The African species *Iodes africana*, previously described (p. 324), is so similar in form and size to the species now under discussion that we unhesitatingly refer this species to *Iodes*. A discussion of the characters of the genus is given on p. 324.

In addition to the well-characterized specimens on which the species is based, there are several so much abraded that no trace of the endocarp wall is preserved, but the internal cast of the locule bears on its surface the impression of the characteristic interlocking cells with papillae. Within the locule-casts the testa cells are preserved, and are exposed either by fracture or by abrasion. The specimens undoubtedly belong to the Icacinaceae, and probably to the species under discussion, but some of them are slightly larger (13 mm. long) than the largest undoubted examples of *I. multireticulata* (12·5 mm.). Such a slight difference is insufficient to place them in a separate species. Thus, whilst they cannot be proved to belong to *I. multireticulata*, the probability that they do is great. The importance of these specimens lies in the fact that some of them were labelled by Ettingshausen "*Sapotacites* sp. 1," and "*Sapotacites* sp. 2," though one of the latter, V. 22595, is an undoubted specimen of *I. multireticulata* (Pl. XV, fig. 8), and shows the characteristic testa and chalaza of the Icacinaceae very clearly. None of the specimens can be referred to the family Sapotaceae.

Another jar, labelled "*Leguminosites crassus* Bowerb." by Ettingshausen, contained two specimens which quite obviously belong to different species, and probably to different genera. One is a well-preserved, flattened, lenticular endocarp, nearly circular in outline. Much of the endocarp wall has been abraded, but the remains of placenta and funicle are present as a knob at one extremity. The surface shows some of the interlocking digitate cells which formed the wall; the locule-lining was formed of equiaxial digitate cells each with a central papilla. In places where the endocarp and locule-cast have been entirely worn away the testa is exposed with its quadrilateral, angular cells. There cannot be the slightest doubt that this specimen belongs to the family Icacinaceae, and its shape and cell-structure suggest that it should be referred to *Iodes multireticulata;* but the outer surface of the endocarp is too abraded to allow of definite ascription to that species. The second specimen belongs to *Icacinicarya ovoidea* (p. 347) and has been grouped with that species. Neither specimen can possibly represent *Leguminosites crassus* Bowerbank, as evidenced by the figures of that species (1840, pl. xvii, figs. 3, 4).

V. 22589 Holotype, figured Pl. XV, fig. 1. An endocarp with part of the carpel wall preserved. It shows the digitate cells of the inner layers and of the lining layer of the carpel, the casts of the papillae on the locule-lining, and the broadly ovate form.

V. 22590 Figured Pl. XV, figs. 2, 3. An endocarp: much of the wall abraded, and the cast partly broken. The remains of the stylar scar and funicular canal are at the apex of the endocarp. Below, the funicle and its canal have been broken away. The specimen is of the common narrowly ovate form.

V. 22591 Figured Pl. XV, fig. 4. An endocarp-cast with remains of the carpel wall showing the apical knob which represents the placenta and termination of the funicular canal. An example of the broader oval form of nut.

V. 22592 Figured Pl. XV, fig. 5. An internal cast of an endocarp, figured to show the typical appearance of much abraded specimens. Narrow ovate form.

V. 22593 Figured Pl. XV, fig. 6. An endocarp-cast showing the mode of splitting for germination.

V. 22594 Figured Pl. XV, fig. 7. An internal cast of an endocarp with the casts of the papillae on the locule.

V. 22595 Figured Pl. XV, fig. 8. An internal cast of a seed with adherent remains of the endocarp-cast at the hilar end (stylar end of endocarp). The seed shows the cells of the testa, the raphe and the chalaza. The specimen was in a jar with two other much worn casts labelled by Ettingshausen "*Sapotacites* sp. 2."

V. 22596 Figured Pl. XV, fig. 9. An endocarp-cast, broken at the apex; a rare inflated form.

V. 22597 Figured Pl. XV, figs. 10, 11. An endocarp-cast, of a rare bilobed form. Labelled by Ettingshausen "*Carpolithes* sp. n. 24."

V. 22598 A well-preserved specimen, with remains of the funicular canal and the style at the apex.

V. 22599 A well-preserved specimen showing successive layers of the endocarp wall, and the internal cast of the seed through gaps in the endocarp and its cast.

V. 22600 Three specimens with variously abraded endocarps.

V. 22601 Two specimens, one broken, with internal casts of the seed. The broken specimen also shows an external cast; the chalaza and micropyle are clearly visible. The more perfect specimen shows the raphe as well as the two scars. In both specimens the seed-cast is lying within the cast of the endocarp, still partially preserved.

V. 22602 Another cast of an endocarp, much worn, and broken to expose the seed-cast within (external and internal surfaces represented on the counterparts).

V. 22603 An internal cast of a seed, and the fragmentary remains of the endocarp-cast which were chipped away from it.

V. 22604 The fractured cast of an endocarp, with the papillae of the locule-lining in profile embedded in the pyrites of the cast.

V. 22605 Seven specimens in various stages of abrasion.

V. 22606 Sixty endocarps and numerous fragments.

All the above are from the Bowerbank Coll., Sheppey. Unless otherwise stated they were in a jar labelled by Ettingshausen "*Carpolithes* sp. nov."

V. 22607 Twenty specimens. *Reid & Chandler Coll.*, Minster, 1928, 1929.

V. 22608 A small endocarp showing the mode of dehiscence. *D. J. Jenkins Coll.*, Herne Bay, 1930.

The following specimens are probably referable to *Iodes multireticulata*, but their condition is such that the determination must remain doubtful. They undoubtedly belong to the Icacinaceae. *All are from the Bowerbank Coll.*, Sheppey.

V. 22609 Two abraded specimens showing casts of seeds, labelled by Ettingshausen "*Sapotacites* sp. 2" (cf. also V. 22595).

V. 22610 Six abraded casts of endocarps labelled by Ettingshausen "*Sapotacites* sp. n. 2."

V. 22611 A much abraded locule-cast. Labelled by Ettingshausen "*Leguminosites crassus* Bowerb.". It may be an exceptionally broad specimen of *I. multireticulata*.

V. 22612 A much abraded and broken endocarp. Labelled by Ettingshausen "*Sapotacites* sp. 1."

V. 22613 Three abraded endocarp-casts. Labelled by Ettingshausen "*Faboidea* Bowerb."

V. 22614 Twelve endocarps in various states of abrasion. Some or all of them may be referable to *Iodes multireticulata*, but their condition is such that the determination must remain uncertain.

Iodes eocenica n. sp.

Plate XV, figs. 12–15.

1879. *Amygdalus eocenica* Ettingshausen (pars), p. 395.

Diagnosis.—Endocarp circular or oval, lenticular in transverse section, surface with a coarse network of broad, low, rounded ridges, enclosing slightly hollowed spaces; locule-lining papillate. Length, 13·5 to 15 mm.; breadth, 12 mm.; thickness, 5 to 6 mm. Seed with testa cells averaging 0·031 mm. in diameter.

Holotype.—V. 22615.

Description.—*Endocarp:* One-loculed, almost circular or oval in outline, flattened so as to be lenticular in transverse section, bisymmetric. Funicle lateral, lying in the endocarp wall from base to apex, where it turns sharply in to the locule to form the apical placenta. Style terminal at the apex (Pl. XV, fig. 15). External surface ornamented with broad, low, rounded ridges forming a coarse network; there is a marked tendency for one or two ribs near the median line on each face to be aligned longitudinally. Spaces between the ribs slightly hollowed. The endocarp wall is fairly thick; the outer layers are formed of parenchyma with fine interlocking digitations; some of the cells measure 0·05 mm. in diameter. There is also a thin inner layer, sometimes separated from the outer layers as the result of fossilization; forming its smooth surface are rather long narrow small interlocking digitate cells. The locule-lining is formed of small polygonal cells, each with a papilla (about 0·016 mm. in diameter) in its centre, so that the surface of the locule is closely and minutely papillate. The spaces between the papillae are approximately equal in diameter to the papillae. Length of one endocarp, 15 mm.; breadth, 12 mm.; thickness (broken), about 6 mm. Second specimen: Length, 13·5 mm.; breadth, 12 mm.; thickness, 6 mm. Third specimen: Length, 13·5 mm.; breadth, 12 mm.; thickness, 5 mm.

Seed: Solitary, conforming in shape to the locule, flattened, oval, slightly pointed at the micropyle. Pendulous from the apical placenta, anatropous, with raphe longitudinal along the middle of one of the flat faces (Pl. XV, fig. 14). Hilum and micropyle closely adjacent; the former marked by a large, circular, rimmed scar from which the raphe originates (Pl. XV, fig. 14). Chalaza a sub-terminal circular scar at the opposite extremity of the seed. Testa thin, formed of close, inflated, square, or angular cells about 0·031 mm. in diameter, but varying from 0·025 to 0·05 mm. These cells are arranged radially around the chalazal and hilar scars. Length of seed, 12 mm.; breadth, 10 mm.; thickness, 4 mm.

REMARKS.—Three specimens labelled "*Amygdalus eocenica*" by Ettingshausen, a name which appears in his published list (1879, p. 395). The nuts present a slight superficial resemblance to some of the Prunoideae on account of their shape and sculpture, but not to *Amygdalus*, and a close inspection of the exterior alone is sufficient to carry conviction that the resemblance to Prunoideae is more apparent than real. In all the members of this section of the Rosaceae there is a marked asymmetry between the two margins. That which carries the funicle is broader than the opposite margin, greatly thickened, and deeply and conspicuously grooved, or striate longitudinally. The general sculpture or ornamentation of the broad surfaces is continued to the apex. In the fossil the two margins are very similar. Possibly in the perfect, unabraded state, that which carried the funicle was somewhat the broader and stouter of the two, but in the slightly worn condition in which the specimens occur, the margins are so similar that it is impossible, unless abrasion is sufficient to expose the funicle, to tell on which side it lies. Moreover, there is no grooving or striation over it as in the Prunoideae. The nuts of *Amygdalus* are not reticulated by ridges as are those of the fossil species, although some of the Prunoideae are.

When the whole structure is taken into account, the impossibility of the fossil being related to the Prunoideae becomes even more evident. In every member of the Prunoideae the funicle gradually approaches the locule, entering it some distance below the apex, so that the seed is attached laterally or sub-apically. In the fossil, as in the Icacinaceae, the funicle does not gradually approach the interior but turns inward suddenly at the extreme apex, so that the seed is suspended from the apex.

The walls of the endocarp of *Amygdalus* are formed of two very distinct coats, both fairly thick, the inner coat being close textured and the outer loose and cavernous; also none of the Prunoïdeae shows a papillate locule-lining. On the contrary, the walls of the fossil are formed of close parenchyma throughout, and the locule-lining is papillate. Both in the Prunoideae and in the fossil, the seed is anatropous, but whereas in the former the raphe is strictly marginal and the chalaza terminal, in the latter the raphe lies on one of the flattened faces and the chalaza is sub-terminal. Moreover, on reaching the chalaza, the raphe in the Prunoideae branches conspicuously over the surface of the testa, whereas in the fossil, the chalaza is represented by a well-defined circular scar. Again the cells of the testa are quite different in *Amygdalus* or *Prunus* from those of the fossil.

It must therefore be inferred that Ettingshausen was misled by a superficial likeness of external form and sculpture, when he placed these nuts in the genus *Amygdalus*. The species affords an instance of the danger of making determinations on so untrustworthy a basis. Experience shows that there are endocarps and seeds so distinctive that they cannot be confused with others, but even in such cases, support in evidence of the determination should be sought, and stated as fully as possible, in order to make the systematic position sure (cf. pp. 27, 28).

The true alliance of the fossil in question is undoubtedly with the Icacinaceae. All the characters described occur in that family. The shape and ornamentation of the nut, with the finely papillate locule-lining, point further to an alliance with the genus *Iodes*.

V. 22615 Holotype, figured Pl. XV, figs. 12–14. An abraded endocarp, with enclosed seed. Now dissected to expose the seed with raphe, chalaza, and hilum. The apex is broken so that the micropyle is not seen.

V. 22616 Figured Pl. XV, fig. 15. An endocarp fractured in part longitudinally, showing the vascular canal (funicle), placenta, and stylar canal.

V. 22617 An endocarp.

All are from the Bowerbank Coll., Sheppey. They were labelled by Ettingshausen "*Amygdalus eocenica*."

Iodes sp.?

Plate XV, figs. 16, 17.

Description.—*Endocarp:* (Sparsely and coarsely pitted externally?), ovate, laterally compressed, bisymmetric. Funicle lateral entering the locule at the apex. Endocarp wall rather thin, formed of parenchyma and lined by a smooth layer of interlocking equiaxial digitate cells, less than 0·1 mm. in diameter, but the outlines are obscure and difficult to measure on the calcite cast.

Seed: Solitary, pendulous, conforming to the shape of the locule. Testa formed of angular, or quadrilateral, inflated cells. Length of locule-cast (virtually of seed), 8·5 mm.; breadth, 6·2 mm.; thickness, 4·1 mm.

Remarks.—One specimen preserved in a block of argillaceous limestone from Assington, Suffolk, containing other fossil fruits, and some shells. Almost all of the carbonaceous endocarp has disintegrated, but the external cast and the internal calcite mould of the nut remain. Both show what appear to be longitudinal rows of pits, one row occurring along the margin and about three on each face.

AFFINITIES.—There can be no doubt from the size and shape of the endocarp, the position of the funicle and placenta, and the cell-structure of endocarp and testa, that the specimen belongs to the Icacinaceae. In size and shape it resembles some of the species of *Iodes* from the London Clay of Sheppey, to which it may possibly belong, but the sculpture of the surface is unlike that of any species we have seen, the rows of pits being smaller, more regular, and more regularly aligned than the hollowed areas in that genus.

V. 22618 Figured Pl. XV, figs. 16, 17. An internal cast of an endocarp in calcite, and the external cast of the same nut in a block of cement stone, from a pit at Assington, Suffolk. *John Brown Coll.*

Genus SPHAERIODES nov.

DIAGNOSIS.—Endocarp globular, coarsely nodular externally, style flanked by a pair of lateral knobs; locule-lining minutely papillate. Length, 10 to 16 mm.; breadth, 10 to 15 mm.; thickness, 10 to 14 mm. Seed with cells of testa but slightly inflated, 0·015 to 0·016 mm. in diameter.

GENOTYPE.—*Faboidea ventricosa* Bowerbank.

Sphaeriodes ventricosa (Bowerbank)

PLATE XV, figs. 18–23.

1840. *Faboidea ventricosa* Bowerbank, p. 116, pl. xvi, figs. 4–6.
1879. *Juglans eocenica* Ettingshausen (pars), p. 394.
1879. *Amygdalus eocenica* Ettingshausen (pars), p. 395.
1879. *Faboidea ventricosa* Bowerbank: Ettingshausen, p. 396.
1879. *? Carpolithes amygdaloides* Ettingshausen, p. 396.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22619.

DESCRIPTION.—*Endocarp:* One-loculed, one-seeded, globular, bisymmetric, thick-walled, coarsely nodular externally (Pl. XV, figs. 20–22). Style terminal at the apex. Funicle thick, lateral, passing from base to apex within the wall of the endocarp, on the external surface of which it forms a conspicuous ridge; the funicle turns into the locule abruptly to form the apical placenta. At the apex of the nut, the ridge and style are flanked by a pair of knobs, one on each side of the placenta These are due to fibrous strands which arise from the funicle and pass directly through the endocarp wall (Pl. XV, fig. 19). Endocarp thick and woody, formed of large parenchymatous cells with irregular or wavy walls. Locule-lining minutely tubercled, the tubercles forming pits on the surface of the internal cast. These tubercles or papillae appear to be about 0·016 mm. in diameter. Length of endocarp, 10 to 16 mm.; breadth, 10 to 15 mm.; thickness, 10 to 14 mm.

Seed: Pendulous from the apical placenta, globular or sub-globular, anatropous; raphe median on one of the flat faces; hilum terminal at the end nearest the apex of the fruit, chalaza a conspicuous circular scar, sub-terminal at the other end (Pl. XV, fig. 23). Testa very thin, formed of minute square or angular cells, only slightly inflated, arranged radially around the chalaza, about 0·015 mm. to 0·016 mm. in diameter. The testa appears to be in close association with, or adherent to the endocarp, hence it is difficult to see. This may be an original character, but is possibly a secondary result of fossilization, the pyrites acting as a cement between the two contiguous surfaces.

AFFINITIES.—A somewhat abraded endocarp of this species was described and figured by Bowerbank under the name *Faboidea ventricosa* (1840, p. 116, pl. xvi, figs. 4–6). Bowerbank's type is still available for study (Pl. XV, figs. 18, 19) in a broken condition, and it is clearly related, generically and specifically, to numerous better preserved and better developed endocarps which he appears not to have recognized as belonging to the same species, although they form a part of the Bowerbank Collection. Our description of the species is largely based on this more complete material, which we have used to supplement the information derived from an examination of Bowerbank's type. An explanation of the descriptive terms which he uses is given on p. 341.

Every character seen in the fossils occurs in the family Icacinaceae, to which they must undoubtedly be referred. They probably belong to the section Iodeae, and may be nearly related to *Iodes*. They differ from the endocarp of this genus in having a series of nodules instead of a series of concavities on the external surface of the endocarp ; also they are more regularly globose than any endocarps of *Iodes* that we have seen. We have therefore given them the distinctive generic name *Sphaeriodes*, as the name *Faboidea*, used by Bowerbank, must be retained for specimens of the character of *F. crassicutis* Bowerbank (see p. 341), which are generically distinct from the species under discussion.

Two typical, well-developed specimens, together with a third specimen of entirely different affinities, were labelled "*Juglans eocenica*" by Ettingshausen. None of the three is referable to *Juglans*, although in their nodular surface and rounded form the two typical specimens have a superficial likeness to the nuts of that genus. But in Juglandaceae there is no lateral funicle, nor is the seed pendulous and anatropous as in the fossil. It is always orthotropous, seated astride a thick axis, always deeply bilobed, and quite commonly four-lobed. Moreover, the cell-structure of the carpel wall, the locule-lining, and the testa, are not those of Juglandaceae. The superficial characters and the lateral funicle within the endocarp wall are somewhat reminiscent of the section Prunoideae of the family Rosaceae. But this alliance is also excluded by the character and cell-structure of the endocarp, the cell-structure of the locule-lining, which in the Prunoideae bears no papillae, the terminal position of the placenta, the position of the raphe on one of the flat faces of the seed, the character of the chalaza, and the cell-structure of the thin testa (cf. p. 331).

V. 22619 Holotype, figured Pl. XV, figs. 18, 19; also figured Bowerbank, 1840, pl. xvi, figs. 4–6 (inverted) as *Faboidea ventricosa*. An abraded endocarp rather less inflated than the normal specimens. The vascular cord running in the wall of the endocarp is exposed by abrasion throughout its length. At the apex the cord shows two characteristic short forks on each side of the placenta and style, which produce the "knobs" described above.

V. 22620 Figured Pl. XV, fig. 20. An endocarp showing the rugose character of the external surface. This is rarely seen so clearly, owing to abrasion.
V. 22621 Figured Pl. XV, figs. 21, 22. An abraded endocarp still showing indications of the external rugosities (a common condition among specimens of *S. ventricosa*).
V. 22622 Figured Pl. XV, fig. 23. An internal cast of a seed showing the chalazal scar. Remains of the locule-cast adhere in places to its surface showing the impression of the papillate locule-lining. Parts of the endocarp wall are also preserved, and one or two fragments have been detached in order to expose the seed more completely.
V. 22623 A typical endocarp much abraded so as to expose the marginal vascular cord throughout its length as it lies in the thickness of the wall, with the two short branches at the apex.
V. 22624–26 Three endocarps fractured longitudinally through the marginal vascular canal. All show the passage into the placenta at the apex. In one of the specimens the basal part of the endocarp and cord are broken (V. 22625). The locules are filled with pyrites.
V. 22627 An internal cast of an endocarp with adherent remains of the endocarp wall. The surface of the cast shows the impression of the papillate locule lining.
V. 22628 Thirty endocarps in various stages of abrasion.
V. 22629 Two endocarps, somewhat worn. These were labelled by Ettingshausen "*Juglans eocenica* sp. n."
V. 22630 A crushed, distorted endocarp, somewhat abraded. Labelled by Ettingshausen "*Amygdalus eocenica*" (cf. p. 329).
V. 22631 Two endocarp-casts, one shows the seed-cast within and both show fragments (some now detached) of the carpel wall. Labelled by Ettingshausen "*Carpolithes* n. sp. 8."
All the above are from the Bowerbank Coll., Sheppey.
V. 22632 Five endocarps. *Reid & Chandler Coll.*, Minster, 1928, 1929.

Section *Phytocreneae* Engler

Genus PALAEOPHYTOCRENE nov.

DIAGNOSIS.—Endocarp oval, compressed or slightly inflated, obscurely pitted externally, the closed inner ends of the pits forming parallel-sided protuberances projecting into the locule; locule-lining not papillate, formed of small polygonal cells.

GENOTYPE.—*P. foveolata* n. sp.

Palaeophytocrene foveolata n. sp.

PLATE XV, figs. 24–32.

1879. *Nelumbium microcarpum* Ettingshausen, p. 395.

DIAGNOSIS.—Endocarp, with surface pits about twelve in the length of the nut and eight in the width. Length, 15 to 27 mm.; breadth, 14 to 17 mm.; thickness, 5·5 to 13 mm. Seed with testa cells inflated 0·05 to 0·15 mm. in diameter.

HOLOTYPE.—V. 22633.

DESCRIPTION.—*Endocarp:* Large, oval, compressed or slightly inflated, thick and woody, obscurely pitted on its outer surface (Pl. XV, figs. 24, 26), the pits being associated with large, conspicuous, vertical-sided protuberances which project into the locule. Style terminal at the apex. Endocarp formed of interlocking cells, which are sometimes difficult to distinguish, but there may be some straight-walled parenchymatous cells among them. One layer of the wall which lies close to the locule (Pl. XV, fig. 31) is formed of flat star-shaped cells, 0·15 mm. in diameter, with interlocking rays. Locule-lining of small polygonal cells 0·025 mm. in diameter. Funicle and placenta not seen owing to the marked abrasion of the endocarp, which is as a rule preserved in patches only, on the surface of the pyrites locule-cast. Length of endocarps, 15 to 27 mm.; breadth, 14 to 17 mm.; thickness, 5·5 to 13 mm.

Seed: Large, solitary, conforming approximately to the shape of the locule. Its surface is dimpled, the dimples corresponding with, but less sharply defined than, the protuberances of the endocarp. Testa thin, formed of closely-set, glistening, inflated cells (Pl. XV, fig. 32), which vary from 0·05 mm. in diameter to 0·15 mm. (very rarely). We were unable to trace the raphe, hilum, micropyle, or chalaza, for the corrugations and dimples of the seed made it impossible to clear its surface from the mud which obscured it.

REMARKS.—Twenty-five nuts are preserved. Nearly all are represented by pyrites casts of the locules. These casts bear on their surfaces conspicuous deep pits, the impressions of the protuberances that project into the locule from the endocarp wall (Pl. XV, figs. 24, 25, 27–29, 30). The wall itself frequently adheres to the cast in larger or smaller patches (Pl. XV, fig. 24), or it may persist as a thin film. Sometimes every trace of it is abraded except the rounded inner ends of the protuberances which have been protected from abrasion because they lie at the bottoms of the pits in the pyrites locule-casts. The testa of the seed is sometimes preserved in carbonaceous material.

AFFINITIES.—When drawing fruits and seeds in Kew Herbarium, we discovered the close correspondence of these fossils with members of the family Icacinaceae, section Phytocreneae. In this section some of the endocarps have protuberances projecting into the locule. They would, therefore, give internal casts similar to the casts of the fossil species. The locule-lining and the inflated cells of the testa in the Phytocreneae are in agreement with the corresponding structures in the fossils. The structure of the endocarp wall is also closely comparable. We discovered, however, that the characters of the fossils are not now combined in any one living genus, but are distributed among the three genera, *Phytocrene* Wall., *Miquelia* Meissn., and *Chlamydocarya* Baill. In all these genera there are endocarps comparable with the fossils in size and shape. In *Phytocrene,* however, the external pits do not form conspicuous tubercles inside the locule, but low rounded elevations, or they may even not appear on the locule-lining at all. They are irregularly distributed as in the fossil. In *Chlamydocarya,* large vertical-sided protuberances occur, but they are elongate longitudinally, and are arranged more or less in longitudinal rows, whereas the tubercles of the fossil are, for the most part, nearly circular in transverse section, and, if arranged in rows, these are very irregular. Occasionally individual tubercles are longitudinally elongate. In *Miquelia* the tubercles are disposed internally in a manner somewhat similar to that of the fossil, but they are conical, with sloping, not vertical sides. The external surface of *Miquelia* is conspicuously ornamented with sharp ridges and projections, no traces of which have been seen in the most perfectly preserved of the London Clay endocarps. Hence the fossil does not correspond exactly with any of these genera. In the disposition of the tubercles or protuberances it comes nearest to *Phytocrene,* and in their form and character to *Chlamydocarya*. We have therefore given it a new generic name, *Palaeophytocrene*, to signify its inclusion in the section Phytocreneae while marking its distinct generic character.

Chlamydocarya and *Phytocrene* are lianas, largely aquatic, the former growing in tropical West Africa, the latter in tropical Asia. *Miquelia* is a liana of the Indo-Malayan region.

In Crow's manuscript catalogue (1810) an endocarp of *Palaeophytocrene foveolata* is illustrated (No. 86). Possibly also a second specimen is depicted (No. 518).

Specimens of *Palaeophytocrene foveolata* were labelled "*Nelumbium microcarpum*" by Ettingshausen. He apparently regarded the locule-casts with their conspicuous pits as the torus of a small *Nelumbium* with sunk receptacles, the pits representing cavities out of which small fruits had fallen.

V. 22633 Holotype, figured Pl. XV, figs. 24, 25. A locule-cast, with part of the endocarp itself still adhering. It shows the difference in appearance between the external and the internal surfaces of the endocarp.

V. 22634 Figured Pl. XV, fig. 26. An endocarp, with the wall still preserved. The small external pits are filled with pyrites, which greatly obscures them.

V. 22635 Figured Pl. XV, figs. 27, 28. A locule-cast. At the upper end part of the endocarp is preserved with the remains of the style.

V. 22636 Figured Pl. XV, fig. 29. A locule-cast from which the endocarp has been completely abraded.

V. 22637 Figured Pl. XV, figs. 30–32. A locule-cast with a thin film of the endocarp, which shows the star-shaped cells. The cast is broken or worn in parts to show the seed lying within.

All the above specimens were labelled by Ettingshausen "*Nelumbium microcarpum* sp. n."

V. 22638 A locule-cast, distorted, as are often the living nuts of the Phytocreneae.

V. 22639 An endocarp, much abraded, so that the locule-cast is exposed at the margin.

V. 22640 A locule-cast, much abraded, so that the pits appear as large excavations. The specimen is now breaking in pieces.

V. 22641 Fifteen endocarps in different stages of abrasion.

All the above are from the Bowerbank Coll., Sheppey.

V. 22642 A locule-cast. *W. Griffith Coll.*, Sheppey.

V. 22643 An imperfect cast of a locule. *Reid & Chandler Coll*, Minster, 1929.

Palaeophytocrene foveolata var. *minima* nov.

Plate XV, fig. 33.

Diagnosis of Variety.—Endocarp differs from that of *P. foveolata* in its smaller size, length 16 mm.; breadth 13 mm., and the fewer and larger pits on its surface, six or seven pits in the length, and five or six pits in the breadth. Seed with rather flat testa cells, 0·015 to 0·016 mm. in diameter.

Holotype.—V. 22644.

Description.—Six oval, compressed nuts which differ from the species just described in their small size and in their fewer and larger pits. We are uncertain whether this difference is accidental or whether it really signifies a distinct variety, but in order to draw attention to the specimens we have described them as such. Remains of the endocarp are preserved on three specimens, the other three represent casts of locules. In several cases the locule-casts are abraded so as to expose the seed-cast within. The testa is formed of rather flat polygonal cells from 0·015 to 0·016 mm. in diameter. Length of largest cast, 16 mm.; breadth, 13 mm.

V. 22644 Holotype, figured Pl. XV, fig. 33. A locule-cast with traces of testa exposed.
V. 22645 Five locule-casts, three of which show remains of the endocarp wall adhering to the surface.
All are from the Bowerbank Coll., Sheppey.

Palaeophytocrene ambigua n. sp.

PLATE XV, fig. 34.

DIAGNOSIS.—Locule-cast with fewer, and actually larger, more funnel-shaped pits than those of *P. foveolata*, arranged in irregular longitudinal rows, about eight or nine in the length, and four or five in the breadth of an endocarp. Length, 22 mm.; breadth, 14·5 mm.

HOLOTYPE.—V. 22646.

DESCRIPTION.—*Endocarp :* The characters of the endocarp are those of *P foveolata*, but the pits on the internal cast are much fewer, and are larger both actually and in proportion to the size of the nut, and the intervening ridges are narrower in proportion to the size of the pits so that the pits are somewhat funnel-shaped. About four or five pits occur in the width of the nut. They show a marked tendency towards alignment in longitudinal rows of about eight or nine pits. Length of cast, 22 mm.; breadth, 14·5 mm.; diameter of pits, about 2 mm. on the internal cast. Cell-structure not sufficiently clearly exposed for measurement.

AFFINITIES.—The species is represented by one perfect locule-cast, with large patches of the woody endocarp still adhering. The material is insufficient for separating this nut generically from those previously described, but the projections from the locule wall are more like those of *Miquelia* than the corresponding projections of *P. foveolata*, both in their tendency to longitudinal alignment and in their more conical form as evidenced by the funnel-shaped impressions on the locule-cast. We have, therefore, described the specimen as a distinct species.

V. 22646 Holotype, figured Pl. XV, fig. 34. A locule-cast, with remains of the carpel wall, showing widely spaced pits, now filled with pyrites. *Bowerbank Coll.*, Sheppey.

Genus STIZOCARYA nov.

DIAGNOSIS.—Endocarp obscurely bisymmetric, pitted externally, the pits containing hairs which arise from the outer surface of the locule-lining; locule-lining formed of equiaxial digitate cells.

GENOTYPE.—*S. communis* n. sp.

Stizocarya communis n. sp.

PLATE XV, figs. 35–42; text-fig. 8.

1879. *Solanites elegans* Ettingshausen, p. 394.

DIAGNOSIS.—Endocarp sub-globose or ovoid, diameter 11 to 14·5 mm. Seed with testa cells much inflated 0·025 mm. in diameter.

HOLOTYPE.—V. 22647.

DESCRIPTION.—*Endocarp :* Sub-globular or ovoid, one-loculed, one-seeded, obscurely bisymmetric, thick-walled, the wall formed of many layers of irregular, digitate, parenchymatous cells. As a result of fossilization the layers tend to separate in a concentric manner. The outer layers are the most compact and are formed of the smallest cells, the outlines of which are rather obscure; the diameter is approximately 0·025 to 0·05 mm. The inner layers become successively more spongy as the cells become larger. The locule is lined by a coat about three or four cells deep of large equiaxial star-shaped interlocking cells 0·1 mm. in diameter, forming a smooth surface (Pl. XV, fig. 42). The endocarp wall is penetrated by numerous long, radially-directed, cylindrical pits of small radius (about 0·2 mm.) containing hairs, each hair having a core of parenchyma encased by compacted strands of fibres (Text-fig. 8, and Pl. XV, fig. 41). These hairs gradually attenuate as they pass towards the interior. They reach, but do not pierce, the lining-layers of star-cells. At their inner extremities they suddenly expand. Style apical. Funicle thick, marginal, passing from the base to the apex within the wall of the endocarp, the funicular canal being lined with digitate cells about 0·016 mm. in

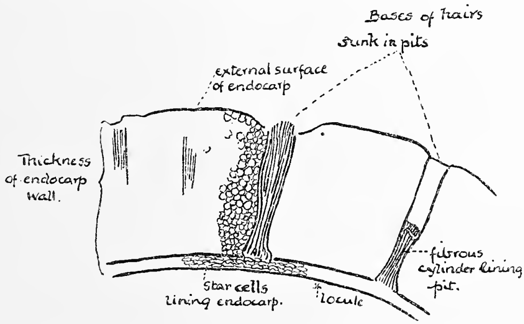


FIG. 8.—*Stizocarya communis*. Diagrammatic section through endocarp wall.

diameter. Diameter of endocarp, 11 to 14·5 mm.; greatest diameter of locule, 9 to 13 mm.; thickness of carpel wall, 1·5 to 2 mm.

Seed: Pendulous from the apex, anatropous. Hilar scar large, well-defined, circular, adjacent to the placenta and style of the endocarp, micropyle near to the hilum, closely associated with the stylar scar, appearing as a circular scar with coarse cells (Pl. XV, fig. 40). Chalazal scar about 0·1 mm. in diameter, at the end of the seed opposite to the hilum. Testa formed of square, oblong or angular cells, much inflated, 0·025 mm. in diameter, radiating from the micropyle and hilum and from the chalaza. Length of typical locule-cast (virtually of seed), 11 mm.; breadth, 9 mm.; thickness, 7 mm.

REMARKS.—This is a common fruit in the London Clay; it is represented by 180 specimens. Owing to various degrees of abrasion different specimens present very different appearances. The most perfect present a pyritized surface on which the ridge or angle associated with the funicle can scarcely be distinguished. The external surface when least worn is smooth and ornamented only by pits which contain the decayed hairs. We do not know to what extent these hairs originally protruded beyond the general external surface of the endocarp, but that they did so to some extent is clearly evidenced by a specimen which we illustrate on Pl. XV, fig. 41. The outer surface of this endocarp is coated by a film of pyrites, except where the hairs protruded. The hairs have now decayed, but their former position is indicated by dimples on the surface of the pyrites. And beneath these dimples the hair-bases are still preserved in the endocarp wall, as can be seen in sections of the specimen (cf. text-fig. 8).

Sometimes the loose-textured parenchymatous cores of the hairs as preserved within the endocarp wall have become impregnated with pyrites ; the surrounding fibrous cylinder, being softer, has subsequently decayed at the surface, leaving the hardened core as a small protuberance surrounded by a circular depression (Pl. XV, fig. 36). In more abraded specimens, hollows tend to coalesce, leaving patches of carpel wall surrounding the worn hairs as upstanding nodules or rugosities (Pl. XV, fig. 37). Thus the external surface of these endocarps may vary greatly as the result of fossilization. The same is also true of the locule-casts. Usually they retain, adhering firmly to them, the layers of star-cells which line the locule, and scattered over the surface of this coat there are numerous small tubercles, the hard pyritized bases of the hairs (Pl. XV, figs. 35, 39, 40, 42). Around the hairs, the star-cells tend to be reduced in size, and drawn out radially. The presence of these tubercle-like hair-bases accounts for Ettingshausen's apt name, when he sorted these specimens, of " prickle-seed."

The species is largely represented by locule-casts such as those described above. They usually show at the apex two minute knobs (Pl. XV, figs. 36, 38), the casts of two characteristic ducts which pierce the endocarp on each side of the stylar canal or placenta, in certain genera of the family Icacinaceae. These locule-casts show clearly the bisymmetry of form because the two valves of the endocarp meet internally at an angle in the plane of symmetry, and this angle is clearly marked on the casts (Pl. XV, fig. 38).

A jar of locule-casts was labelled " *Solanites elegans* " by Ettingshausen, and the name appears in his list (1879, p. 395).

One specimen was figured by James Sowerby (1809, pl. 300, top row, left-hand figure), but no name or description was given.

A specimen was also drawn by Crow in his manuscript catalogue (designation DZE).

Affinities.—The character and form of the endocarp, the position of the funicle, placenta, hilum, micropyle, raphe, and chalaza, the pits with hair-bases, and the highly characteristic cell-structure of the endocarp-wall, locule-lining layers, and testa, leave no doubt whatever that these fossils belong to the Icacinaceae, and to the section Phytocreneae. We at first experienced great difficulty in relating them to a genus or section within the family because for a long time we supposed that the " prickles " on the locule-casts represented punctations on the locule wall, and no such structures occur in the living endocarps of the Icacinaceae. It was only after careful study of many specimens showing differences in the degree of pyritization and abrasion that we realized that such was not the true origin of the " prickles," but that, as we have just seen, they are, in reality, casts of the inner ends of the hairs and hair-canals which arise from the outer surface of the star-cell layer. As a result of pyritization, when the outer layers of the endocarp decay and perish, the hairs and casts of the hair-canals remain fused with the star-cell layer, breaking transversely at the point of their smallest diameter, close to their swollen bases. The hard pyritized little casts consequently remain as " prickles " or small tubercles on the surface of the locule-casts which, be it noted, are not the true locule-casts, but locule-casts covered by the star-cell layers.

This interpretation of the specimens at once made the relationship clear, for in the section Phytocreneae the outer layers of the endocarp are pierced by canals, which vary in depth and diameter in different genera and species. In species of *Phytocrene* which, like the fossil, has a thick-walled endocarp, the locule surface is smooth, and there is no indication of the position of the hairs on its surface. In *Chlamydocarya*, *Pyrenacantha*, and *Miquelia*, which have thin-walled endocarps, the surface of the locule is covered by small protuberances, or, sometimes, long spines, which are the inner blind ends of hair-canals in the outer layers of the endocarp. The fossils appear to be intermediate in character between *Pyrenacantha* and *Phytocrene*, for although they differ from *Pyrenacantha* in the absence of spines projecting into the locule, they resemble it in the number and uniform disposition of the pits on the external surface, and in their length, slenderness, and circular section. They resemble species of *Phytocrene* in the absence of internal spines, but the pits are much smaller in cross-section, both absolutely and in proportion to their length, are much greater in number, and are more regular in their form. They also differ from both these living genera in the definite association of a hair-base with each pit and in the almost globular shape of the nuts. Whilst placing the fossil in the section Phytocreneae, we have therefore given it a new generic name, *Stizocarya*.

V. 22647 Holotype, figured Pl. XV, figs. 35, 42. An endocarp, fractured to show the internal cast with " prickles " (pyritized hair-bases which arise from the inner layers of the endocarp wall), the digitate cells of the adherent inner layers of the endocarp, the funicle (broken below), and the placenta. The locule-cast is partly fractured so that the cast of the seed inside is exposed.

V. 22648 Figured Pl. XV, fig. 36. An endocarp, somewhat abraded so that the funicle is exposed at the apex, and broken away below. On each side of the placenta at the apex are two small pyrites knobs (casts of minute canals one on each side of the placenta). The canals which traverse the endocarp wall radially are here seen as small knobs sunk each in a tiny pit, due to differential weathering of the contained pyritized hair-bases.

V. 22649 Figured Pl. XV, fig. 37. An endocarp, somewhat more abraded than the preceding. Irregular decay of the surface has resulted in a rugose appearance. The hair-bases within the wall constitute the centres of the rugosities.

V. 22650 Figured Pl. XV, fig. 38. A locule-cast with the innermost layers of the carpel wall adhering. One of many locule-casts labelled " *Solanites elegans* " by Ettingshausen.

V. 22651 Figured Pl. XV, fig. 39. Another locule-cast similarly abraded. The surface is covered with small prominences—the bases of the hairs which pierce the endocarp wall. The appearance is typical, most of the known species being in this condition.

V. 22652 Figured Pl. XV, fig. 40. An internal cast of a seed, broken at the chalazal end, with adherent remains of the locule-cast with its typical small prominences. The seed shows the testa, hilum, and micropyle.

V. 22653 Figured Pl. XV, fig. 41. An endocarp, fractured to show the structure of the wall as seen in transverse section. The radial canals with hair-bases are clearly seen.
V. 22654 An internal cast of a seed, with adherent remains of the locule-cast, showing testa and chalaza.
V. 22655 Two endocarp casts, showing the typical appearance due to the preservation of the inner layers of the carpel wall and the hair-bases. One of the casts is chipped away so as to show the seed lying within.
V. 22656 100 endocarps in various stages of abrasion, and a number of fragments.
V. 22657 Fifty endocarps, chiefly much abraded. Labelled by Ettingshausen "*Solanites elegans*" (cf. also V. 22650).
All the above are from the Bowerbank Coll., Sheppey.
V. 22658 Twenty endocarps. *Reid & Chandler Coll.*, Minster, 1928, 1929.

Stizocarya oviformis n. sp.

PLATE XVI, figs. 1, 2.

DIAGNOSIS.—Locule-cast broadly ovoid, broader than long. Seed, 7·5 mm. long; 8 mm. broad; 6·7 mm. thick.

HOLOTYPE.—V. 22659.

DESCRIPTION.—*Endocarp:* Broadly ovoid, the greatest axis lying in the plane of the funicle at right angles to the axis passing through the attachment and style. Except for its broad form, which may perhaps be the result of distortion either during growth or in fossilization, and for its smaller size, the specimen differs in no respect from the endocarps of *S. communis* (p. 336).

Seed: Testa similar to that of *S. communis.* Length of seed, 7·5 mm.; greatest breadth (in plane of funicle), 8 mm.; greatest thickness (at right angles to plane of funicle), 6·7 mm.

REMARKS.—One specimen, the internal cast of the seed with fragmentary remains of the endocarp. We are uncertain whether this specimen is a distorted and undersized specimen of *S. communis*, a variety of that species, or a distinct species.

V. 22659 Holotype, figured Pl. XVI, figs. 1, 2. An internal cast of a seed with remains of the endocarp. *Bowerbank Coll.*, Sheppey.

Section unknown *(Icacinaceae)*

Genus FABOIDEA Bowerbank emend.

1840. Fossil Fruits and Seeds of the London Clay, p. 98.

DIAGNOSIS.—Endocarp transversely oval, compressed, surface obscurely corrugate. Length, 15 to 19 mm.; breadth, 19 to 20 mm.; thickness, 7 to 14·5 mm.; thickness of endocarp wall, 1·5 to 3·5 mm. Seed with testa cells measuring 0·016 to 0·025 mm.

GENOTYPE.—*Faboidea crassicutis* Bowerbank.

DISCUSSION.—In making the following observations on Bowerbank's genus we must note that some of his figured specimens have been preserved, and that consequently we have been able to study them.

Owing doubtless to similarity in outline to the seeds of certain Leguminosae, Bowerbank was led to regard these fossils as seeds, but he was at pains to point out that they did not agree with leguminous seeds in structure.

A careful examination of his descriptions, figures, and specimens, shows that his descriptive terms must be interpreted as follows: "seed" = endocarp; "testa" = endocarp wall; "nucleus" = locule-cast; "funiculus" = funicle; "embryo" = internal cast of seed; "point of insertion of funiculus" = placenta; "front of seed" or "hilum" = apex of endocarp or style. All his figures * are arranged sideways so that the attachment and style of the endocarp, and the chalaza and hilum of the seed, are represented at the sides, and not respectively at the bottom and top of the picture, while the funicle is always depicted at the top. Hence all need to be turned through a right angle in order to be properly understood. He was evidently far more impressed by the lenticular form than by the disposition of the various organs.

Thanks to a previous acquaintance with the fruits of the family Icacinaceae, we were at once able to recognize their characteristic features in these fossils, and to re-interpret the specimens by comparison with living material. This enabled us to grasp the true anatomical significance of the structures observed, and in the light of the information thus obtained, we were obliged to amend Bowerbank's genus *Faboidea*.

Specimens from the London Clay which appear to have belonged to *Faboidea* were figured by Parsons (1757, pl. xv, figs. 10, 11; pl. xvii, fig. 7), and Pennant (1801, pl. opp. p. 88, figs. 10, 11, copied from Parsons).

Faboidea crassicutis Bowerbank

Plate XVI, figs. 3–10.

1840. *Faboidea* Bowerbank, p. 99, pl. xiv.
1840. *Faboidea crassicutis* Bowerbank, p. 106, pl. xv, figs. 6–8.
1840. *Faboidea longiuscula* Bowerbank, p. 104, pl. xv, figs. 1, 2.
1840. *Faboidea crassa* Bowerbank, p. 105, pl. xv, figs. 3–5.
1840. *Faboidea planodorsa* Bowerbank, p. 107, pl. xv, figs. 9, 10.
1840. *Faboidea symmetrica* Bowerbank, p. 108, pl. xv, figs. 11–13.
1840. *Faboidea plana* Bowerbank, p. 108, pl. xv, figs. 14, 15.
1840. *Faboidea marginata* Bowerbank, p. 109, pl. xv, figs. 16–19.
1840. *Faboidea semicurvilinearis* Bowerbank, p. 110, pl. xv, figs. 20–22.
1840. *Faboidea larga* Bowerbank, p. 111, pl. xv, figs. 23, 24.
1840. *Faboidea complanata* Bowerbank, p. 112, pl. xv, figs. 25–27.
1840. *Faboidea subdisca* Bowerbank, p. 113, pl. xv, figs. 28–30.
1840. *Faboidea oblonga* Bowerbank, p. 114, pl. xv, figs. 31–33.
1840. *Faboidea ovata* Bowerbank, p. 115, pl. xvi, figs. 1–3.
1840. *Faboidea robusta* Bowerbank, p. 117, pl. xvi, figs. 7–9.
1840. *Faboidea pinguis* Bowerbank, p. 117, pl. xvi, figs. 10, 11.
1840. *Faboidea subrobusta* Bowerbank, p. 118, pl. xvi, figs. 12–14.
1840. *Faboidea planimeta* Bowerbank, p. 119, pl. xvi, figs. 15–17.
1840. *Faboidea quadrapes* Bowerbank, p. 120, pl. xvi, figs. 18, 19.
1840. *Faboidea bifalcis* Bowerbank, p. 120, pl. xvi, figs. 20, 21.
1840. *Faboidea tenuis* Bowerbank, p. 121, pl. xvi, figs. 22, 23.
1840. *Faboidea subtenuis* Bowerbank, p. 122, pl. xvi, figs. 24, 25.
1840. *Faboidea rostrata* Bowerbank, p. 122, pl. xvi, figs. 26, 27.

* Except pl. xvi, figs. 4–6, which belong to a different genus (see p. 331).

1840. *Faboidea doliformis* Bowerbank, p. 123, pl. xvi, figs. 28, 29.
1840. *Faboidea acuta* Bowerbank, p. 123, pl. xvi, figs. 32, 33.
1854. *Faboidea semicurvilinearis* Bowerbank: Mantell, p. 178, fig. 42 (5 and 6).
1854. *Faboidea bifalcis* Bowerbank: Mantell, p. 178, fig. 42 (7).
1879. *Faboidea crassicutis*, etc., Bowerbank (as above): Ettingshausen, p. 396.
1879. *Elaeis eocenica* Ettingshausen (pars), p. 393.
1879. *Theobroma Nimrodis* Ettingshausen, p. 395.
1879. *Bauhinia primigenia* Ettingshausen (pars), p. 396.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22660.

DESCRIPTION.—*Endocarp:* Transversely oval. Flattened, bisymmetric about a plane which includes the two major axes and the funicle, dehiscing along this plane into symmetrical halves. Attachment situated on one of the long margins, style near the middle of the opposite margin. External surface, of which the cells have perished, marked by a few irregular nodular corrugations which are directed from attachment to style. Endocarp wall extremely thick, measuring in Bowerbank's type of *Faboidea crassicutis* (1840, p. 106, pl. xv, figs. 6–8), 1·5 mm. in the thinnest and 3·5 mm. in the thickest part, formed of close parenchyma, the cells of which are obscure; the locule-lining, formed of a smooth layer of small interlocking digitate cells (about 0·033 mm. in diameter), has a papillate surface. We were unable to discover whether each of the cells bears a papilla, as in some of the Icacinaceae. The thick funicle is marginal (Pl. XVI, figs. 5, 6), and passes within the thickness of the wall from the base to the apical placenta. The funicular canal is lined with large cells. Length of largest and most perfect endocarp, 18 mm. from attachment to style; greatest diameter, 25 mm.; thickness, 7 mm. The range of the external dimensions is deceptive as it depends on the degree of abrasion of the surface, but the average size probably lies within the following measurements. Length from attachment to style, 15 to 19 mm.; greatest diameter, 19 to 25 mm.; thickness, 7 to 14·5 mm.

Seed: Transversely oval, somewhat compressed, pendulous from the apex, anatropous, with hilum and micropyle closely adjacent at one end (Pl. XVI, fig. 8), the large chalaza, about 1 to 2 mm. in diameter, at the opposite end, and the raphe sub-median on one of the flattened faces; in one specimen, but not in all, the raphe lies in a deep groove which bisects the face unequally (Pl. XVI, figs. 7, 8). Testa formed of small, inflated, quadrangular cells (0·016 to 0·025 mm. in diameter). Length of locule-cast (equivalent in form to the seed), 11 to 18 mm.; greatest diameter, 14 to 19 mm.; thickness, 5 to 9 mm.

REMARKS.—The species is very abundant. There are over 120 specimens, which vary greatly in form, size, and appearance. In part the variability is natural, such as can be seen in any living species when a large number of fruits or seeds are examined, but in part it is a secondary result of fossilization and abrasion. In almost every specimen fine pyrites has penetrated into the locule and has there consolidated, forming a hard nucleus. The endocarp outside, although impregnated with pyrites, is softer and less resistant than the hard locule-cast. In consequence it is always abraded in a greater or lesser degree. The most abundant specimens seem to be those in which the whole of the endocarp has either been worn away from the cast or has been detached from it. Perfect preservation is very rare, but between the two extremes of perfect endocarps on the one hand and locule-casts on the other there is a large number of specimens showing every degree of abrasion.

AFFINITIES.—The anatomy and cell-structure of both endocarp and seed leave no doubt at all that this fruit belongs to the Icacinaceae and not to the Leguminosae as Bowerbank supposed. It shows every character of the former family and none of the latter. The laterally compressed fruit dehiscing into two symmetric valves, the thick funicle running in the carpel wall to the apical placenta, the interlocking digitate cells of the endocarp, the pendulous seed, with hilum and closely adjacent micropyle marginal at one extremity, and chalaza marginal at the other, the testa with its inflated angular cells, are all typical of the family Icacinaceae.

The papillate locule we have seen in the genus *Iodes* alone, but the broadly oval form of the fossil and its smooth surface distinguish it very definitely from any living *Iodes* known to us. It cannot therefore be referred to that genus. Endocarps that are broader than long occur in *Rhaphiostyles* Planch., a native of west tropical Africa; but in *Rhaphiostyles* the transverse section is a broad oval with the cut funicle at one end of the shortest axis, while in the fossil it is a long oval with the cut funicle at one end of the longest axis.

This transverse broadening of the fruit is a very rare character in the Icacinaceae, but while the shape alone seems to exclude the fossil from any living genus, we do not think it can exclude it from the family.

The London Clay specimens from Sheppey were divided by Bowerbank into twenty-five species, of which *F. ventricosa* was one. As this species does not agree with the typical, transversely-oval, compressed specimens on which the genus, and the bulk of the species originally described, were based, we have excluded it from *Faboidea* (see *Sphaeriodes ventricosa*, p. 332). Of the remaining twenty-four species, Bowerbank himself regarded seven as provisional because they were based on locule-casts ("nuclei") only. These seven were *F. quadrapes, F. bifalcis, F. tenuis, F. subtenuis, F. rostrata, F. doliformis, F. acuta*. The other seventeen species have part at least of the endocarp ("testa") preserved. The division into species was founded on what we recognize now as variations of wear and tear, and on slight differences of shape. We can see no evidence for the occurrence of more than one species among these twenty-four; they show no differences either in anatomy or cell-structure. We have, therefore, united them as *F. crassicutis* Bowerbank, retaining this name in preference to any other, because under it Bowerbank described the least abraded specimen we have seen, and it is, moreover, highly appropriate to the fruit with its thick wall.

The accuracy and skill of Sowerby's drawings have enabled us to identify many of Bowerbank's types which have long been lost among an assortment of unfigured fruits.

V. 22660 Holotype, figured Pl. XVI, fig. 3. Also figured Bowerbank (1840, pl. xv, figs. 6–8). A large endocarp, perfect when figured originally, but with the apex broken when it came into our hands.

V. 22661 Figured Pl. XVI, fig. 4. An endocarp with the wall largely preserved.

V. 22662 Figured Pl. XVI, fig. 5. An endocarp, fractured longitudinally so as to expose the funicular canal in the thickness of the wall. The endocarp wall is somewhat abraded.

V. 22663 Figured Pl. XVI, fig. 6. A locule-cast with the cast of the funicular canal (virtually equivalent to the funicle) attached to it. The point where the funicle merges into the locule-cast marks the placenta.

V. 22664 Figured Pl. XVI, figs. 7, 8. An internal cast of a seed from which the locule-cast which surrounded it has been removed. The raphe, hilum and chalaza are preserved, and the cells of the testa are clearly shown.

V. 22665 Figured Pl. XVI, fig. 9. A cast of a small endocarp. *D. J. Jenkins Coll.*, Herne Bay, 1930.

V. 22666 Figured Pl. XVI, fig. 10. A locule-cast, now broken, with a small patch of endocarp preserved, and part of the fibro-vascular bundle. The pitted impression of the characteristic papillate locule-lining is clearly seen, as are the characteristic testa-cells where the cast of the seed is exposed. Ettingshausen labelled this specimen "*Theobroma* sp. 1," and he publishes the name "*Theobroma Nimrodis*" in his provisional list (1879, p. 395). The specimen undoubtedly belongs to Icacinaceae, and its form and characters relate it to *Faboidea crassicutis*.

V. 22667 Figured Bowerbank (1840, pl. xiv, fig. 7) as *Faboidea* sp. A locule-cast with half of the endocarp wall preserved.

V. 22668 Figured Bowerbank (1840, pl. xv, figs. 3–5) as *Faboidea crassa*. An endocarp, fractured longitudinally. It shows the thick wall, traces of the funicle, and a locule-cast.

V. 22669 Figured Bowerbank (1840, pl. xv, figs. 16–18) as *Faboidea marginata*. An abraded endocarp.

V. 22670 Figured Bowerbank (1840, pl. xv, figs. 20, 21) as *Faboidea semicurvilinearis*. A worn endocarp. The wall is so abraded that the cast of the locule is exposed at the margin.

V. 22671 Figured Bowerbank (1840, pl. xvi, figs. 12–14) as *Faboidea subrobusta*. A worn endocarp with the locule-cast protruding through the wall.

V. 22672 Figured Bowerbank (1840, pl. xvi, figs. 20, 21) as *Faboidea bifalcis*. A locule-cast.

V. 22673 Figured Bowerbank (1840, pl. xvi, figs. 22, 23) as *Faboidea tenuis*. A locule-cast.

V. 22674 Figured Bowerbank (1840, pl. xvi, figs. 24, 25) as *Faboidea subtenuis*. A locule-cast.

V. 22675 Figured Bowerbank (1840, pl. xvi, figs. 26, 27) as *Faboidea rostrata*. A locule-cast. Bowerbank noted (p. 122) that a small portion of the "nucleus" [locule-cast] had broken away exposing the "trapeziform reticulations" of the "embryo" [seed]. Since he wrote that description, the bulk of the locule-cast has become detached, showing more or less completely the internal cast of the seed within.

V. 22676 Figured Bowerbank (1840, pl. xvi, figs. 28, 29) as *Faboidea doliformis*. A locule-cast, now broken.

V. 22677 Figured Bowerbank (1840, pl. xvi, figs. 32, 33) as *Faboidea acuta*. An internal cast of an endocarp.

V. 22678–79 Two specimens. Both are endocarps with casts of the locule and remains of the funicle; part of the endocarp wall is broken away, hence the locule-cast is exposed in both specimens.

V. 22680 An endocarp, somewhat abraded, and two casts of locules from which the endocarp wall and the cast of the funicular canal have been broken.

V. 22681 The remains of a locule-cast which has been chipped away to expose the seed-cast within. The hilum can be seen quite clearly, and the raphe is also visible.

V. 22682–83 Forty specimens with part at least of the endocarp wall preserved (V. 22682) and about sixty locule-casts and one seed-cast (V. 22683). Some were labelled by Ettingshausen "*Faboidea* Bowerb." and "*Elaeis eocenica*."

V. 22684 Three locule-casts, one imperfect, labelled, and listed, by Ettingshausen "*Bauhinia primigenia*" (1879, p. 396). The specimen shows all the characters of *Faboidea crassicutis*.

All the above specimens (except V. 22665) *are from the Bowerbank Coll.*, Sheppey.

V. 22685 One locule-cast. *Reid & Chandler Coll.*, Minster, 1929.

Genus ICACINICARYA nov.

Diagnosis.—A form-genus to include species possessing endocarps and seeds showing the generic characters of Icacinaceae (see p. 322), but which cannot be related definitely to any particular genus or section of the family.

Icacinicarya platycarpa n. sp.

Plate XVI, figs. 11–18.

1879. ? *Carpolithes Nimrodis* Ettingshausen, p. 396.

Diagnosis.—Endocarp almond-shaped or circular in outline, flattened lenticular in transverse section, with a median rib flanked by about forty shallow depressions separated by a network of low rounded ridges; cells of endocarp from 0·016 to 0·05 mm. in diameter, not digitate; locule-lining not papillate. Length, from 16 to 26 mm.; breadth, 11·5 to 21 mm.; thickness, 10 mm. Seed with testa cells but slightly inflated, measuring 0·025 mm. in diameter.

Holotype.—V. 22686.

Description.—*Endocarp:* Bisymmetric, large, compressed, varying in outline from almond-shaped to nearly circular (Pl. XVI, figs. 11–15), lenticular in transverse section. External surface ornamented with a sub-median rib flanked by numerous (? about 40) shallow depressions separated by low rounded ridges which form a coarse network (Pl. XVI, figs. 11, 14, 16). Funicle marginal, placenta apical. The endocarp (which is very rarely preserved) is woody, very close-grained and formed of small cells (0·016 to 0·05 mm. in diameter) with no appearance of digitation, although some of the cells show sinuous outlines. No traces of papillae have been seen on the locule-lining. The seed is solitary and pendulous from the apex. The dimensions of several specimens are as follows:

(1) Length, 20 mm.; breadth, 17 mm.; thickness, 10 mm.; thickness of endocarp wall, 1·5 mm.
(2) Length, 16 mm.; breadth, 12·5 mm.
(3) Length, 20·5 mm.; breadth, 14 mm.
(4) Length, 22 mm.; breadth, 21 mm.
(5) Length, 24 mm.; breadth, 20 mm.
(6) Length, 25 mm.; breadth, 17 mm.
(7) Length, 26 mm.; breadth, 11·5 mm.

Seed: Anatropous; the hilar scar, which is at one end of the seed, is circular and slightly depressed, and lies close beneath the style and placenta; the chalaza, which is rather obscure, lies at the end of the seed opposite to the hilum; the raphe lies on one of the flat faces and may either form a shallow depression, or a longitudinally striate band. The testa is thin, formed of small oblong or polygonal cells (about 0·025 mm. in diameter) which are only slightly inflated, and on the whole smaller, and certainly flatter than the cells of *Iodes multireticulata* (p. 326). Usually the seed fills the locule, but sometimes it has collapsed and has shrunk from the locule wall.

Embryo: Large, straight, evidently having large, flat, superposed cotyledons which occupied the entire length of the seed. Radicle obscure, directed towards the style. The embryo is only preserved in one specimen. It occurs as an impression within the pyrites-cast which fills the cavity of the seed (Pl. XVI, fig. 18). Its cell-structure is obscure, but traces of large irregular cells can be detected.

Remarks.—About 100 specimens, as well as fragments. The majority of the specimens are pyrites-casts of locules (Pl. XVI, figs. 11, 13, 15). In some cases the cast forms a solid infilling to the locule, in others merely a shell lining it. In some specimens fragmentary remains of the endocarps are preserved (Pl. XVI, fig. 14), in others the worn endocarp merely persists as a film over the surface of the cast, Certain specimens show a laterally directed knob of pyrites at the apex which is a cast of the extreme distal end of the funicular canal (Pl. XVI, fig. 15), but as a rule the canal is removed by abrasion of the endocarp. In a few specimens the seed is represented by an internal cast of the testa which lies within the locule-cast (Pl. XVI, figs. 13, 16, 17).

AFFINITIES.—The general form, the sculpture of the endocarp, the position of the placenta and funicle, the character of the seed and testa, the position of the hilum, raphe, and chalaza, and the form of the embryo all indicate that the fossil belongs to the family Icacinaceae. It is somewhat similar in general appearance to *Iodes multireticulata* (p. 325), but differs in the cell-structure of its endocarp and testa, in the absence of papillae on the locule-lining, and in its much greater size.

It resembles in size, form, and sculpture the endocarps of the living genus *Sarcostigma* Wight et Arn., more especially of *S. edule* Kurz. and *S. Kleinii* Wight et Arn. But the cells forming the endocarp of *Sarcostigma* are coarser, and the endocarp is of a more spongy texture. We are therefore at a loss to know its relationship.

An unnamed specimen figured by James Sowerby in 1809 (pl. 300, middle figure in the second row from top of page) appears to represent this species, as does also the figure indexed as S in Crow's manuscript catalogue (1810).

V. 22686 Holotype, figured Pl. XVI, fig. 11. A typical cast of a locule with the remains of the endocarp wall as a film over the surface.

V. 22687 Figured Pl. XVI, fig. 12. A locule-cast, showing the broad subcircular form.

V. 22688 Figured Pl. XVI, fig. 13. A locule-cast, showing the narrow obovate form and traces of the internal cast of the seed.

V. 22689 Figured Pl. XVI, fig. 14. A locule-cast, showing the adherent remains of the thick ornamented carpel wall.

V. 22690 Figured Pl. XVI, fig. 15. A locule-cast, showing the small apical asymmetric projection marking the placenta and inner end of the funicular canal.

V. 22691 Figured Pl. XVI, fig. 16. A locule-cast, broken all around the margin and showing the internal cast of the seed lying within.

V. 22692 Figured Pl. XVI, fig. 17. An internal cast of a seed, showing the raphe, hilum, and testa. The chalaza can also be seen but it is somewhat obscure. Adherent remains of the endocarp are preserved as patches on the surface.

V. 22693 Figured Pl. XVI, fig. 18. A cast of a locule and seed. This has split longitudinally and shows the impression of the embryo inside. The specimen is poorly preserved and is falling to pieces.

V. 22694 Five well-preserved locule-casts; some show the cast of the seed where the locule-cast is thin or abraded.

V. 22695 Eighty-five casts of locules; in some, part of the endocarp wall is preserved, in some the cast of the seed can be seen. There are also a number of fragments and broken specimens. Many of these specimens were in a jar inscribed "*Carpolithes* sp. n. 5."

V. 22696 A worn and broken locule-cast labelled by Ettingshausen "*Faboidea symmetrica* Bow." bears no resemblance to Bowerbank's species.

V. 22697 An endocarp with much of the carpel wall preserved. It may belong to this species, but, if so, it is rather more inflated than is normally the case.

All are from the Bowerbank Coll., Sheppey.

Icacinicarya ovoidea n. sp.

PLATE XVI, figs. 19–21.

1879. *Leguminosites crassus* Bowerbank : Ettingshausen (pars), p. 396.

DIAGNOSIS.—Endocarp ovoid, ornamented with a few ridges and hollows; cells of locule-lining digitate, without papillae. Length, 11·5 mm.; breadth, 7·5 mm.; thickness, 6 mm. Seed with testa formed of two layers, the outer of sinuously arranged cells 0·1 mm. long and 0·025 to 0·05 mm. broad, the inner of square or polygonal cells 0·025 mm. in diameter.

HOLOTYPE.—V. 22698.

DESCRIPTION.—*Endocarp*: One-loculed, ovoid or slightly fusiform, bisymmetric, irregularly sculptured externally with a coarse network of a few ridges and hollows; a marginal rib carries the funicle which passes to an apical placenta. The endocarp dehisces into symmetrical halves along this rib. Wall formed of digitate cells; locule-lining also formed of a layer of large flat digitate cells (without central papillae) which are elongate longitudinally along the lateral margins and transversely at the ends of the endocarp (Pl. XVI, fig. 21); elsewhere they appear to be equiaxial, about 0·1 mm. in diameter. Seed solitary. Length (abraded), 11·5 mm.; breadth, 7·5 mm.; thickness, 6 mm.

Seed: Conforming in shape to the locule, ovoid, anatropous, with a broad, flat, rather sinuous raphe, which is sometimes median on one of the faces and sometimes nearer to one of the margins (Pl. XVI, fig. 19); chalaza terminal or subterminal, very large, round and conspicuous, appearing as a circular disc with a raised rim and fine striae radiating from its centre. Testa formed of two layers, the outer layer of large, long, deep, very irregular cells arranged in a tortuous manner. These cells are commonly 0·025 to 0·05 mm. broad and about 0·1 mm. long. The layer is usually more or less carbonaceous, and the raphe is associated with it. The inner layer is preserved only as an impression; it is formed of small, square, oblong or polygonal cells (as is the testa of many species of Icacinaceae) 0·025 mm. in diameter.

AFFINITIES.—This species, represented by two (? or more) specimens, undoubtedly belongs to the Icacinaceae as is evidenced by the general character and anatomy of the endocarp and seed. The endocarps differ from those of other London Clay species (except *Icacinicarya foveolata* and *Sphaeriodes ventricosa*) in their inflated form. They differ also in their tendency to be fusiform in shape, and in the presence of the layer of large tortuous cells which form the outer coat of the testa. This structure is found in the seeds of the only two genera of the section Icacineae which we were able to study microscopically. We have not seen it in any other section of the family Icacinaceae; but this may be because material for detailed examination is scarce.

In *Villaresia* Ruiz. & Pav., a South American genus, the tortuous cells belong to the inner smooth layer of the hard endocarp, and to the soft outer layer of the testa which is often adherent to it. In this genus they are very much larger, more tortuous and more conspicuous than they are in the fossil. In some species of *Mappia* Jacq. they are also seen, but not apparently in all. In *M. tomentosa* Miers they are present, but are somewhat obscure and rather smaller than in the fossil.

Both *Villaresia* and *Mappia* may have inflated ovoid endocarps comparable in size and shape with the fossil species. But whereas the inner layer of the testa of *Mappia* is identical with that of the fossil, that of *Villaresia* is unlike it.

Such evidence as is available, therefore, suggests that the specimens belong to the section Icacineae, and are possibly closely related to *Mappia*, but since the determination is based largely on the microscopic character of the testa, we cannot refer them definitely to this genus in the absence of fuller knowledge of the cell-structure of other allied living genera. *Mappia* is found in the tropics of Asia, Africa, and America.

V. 22698 Holotype, figured Pl. XVI, fig. 19. A locule-cast, much abraded so that the cast of the seed is exposed within. The raphe is clearly seen as are also the two coats of the testa. The specimen was labelled by Ettingshausen "*Leguminosites crassus* Bow.", but it in no way resembles Bowerbank's species.

V. 22699 Figured Pl. XVI, figs. 20, 21. A locule-cast, now broken, showing the digitate cells of the locule-lining and the testa on the seed-cast within.

V. 22700 A small, somewhat distorted endocarp, now broken, which may possibly belong to *Icacinicarya ovoidea*.

V. 22701 Six abraded casts of locules or seeds which may belong to *Icacinicarya ovoidea*.

All are from the Bowerbank Coll., Sheppey.

Icacinicarya ovalis n. sp.

PLATE XVI, figs. 22, 23.

DIAGNOSIS.—Endocarp oval in outline, inflated, surface pits arranged more or less regularly in longitudinal rows; locule-lining formed of digitate cells 0·1 to 0·125 mm. in diameter, not papillate. Length, 14 to 15 mm.; breadth, 12 mm. Seed with testa showing occasional strands of fibres over an outer layer of polygonal cells, and an inner layer of square or polygonal cells 0·016 to 0·025 mm. in diameter.

HOLOTYPE.—V. 22702.

DESCRIPTION.—*Endocarp:* Oval, bisymmetric, lenticular in transverse section ornamented with numerous, irregular, wide pits separated by low rounded ridges which are disposed in more or less straight or curvilinear longitudinal rows (Pl. XVI, fig. 22). Endocarp wall thick, formed of interlocking digitate cells; locule-lining smooth, formed of large, flat, interlocking, digitate cells about 0·1 to 0·125 mm. in diameter including the digitations. Funicle not seen. Seed solitary. Length of endocarp, 14 to 15 mm.; breadth, 12 mm.

Seed: Apparently conforming to the locule in shape, but now collapsed and shrunken so as not to fill it. Testa with occasional strands of fibres on its outer surface, within which are remains of coarse polygonal cells, lined internally by a layer of small, irregular, square or polygonal cells about 0·016 to 0·025 mm. in diameter.

AFFINITIES.—Three specimens and one doubtful one. In all, the endocarp is preserved in a greater or lesser degree, but in two it is broken so as to expose either the locule-lining, or the testa, or both.

The form and sculpture of this nut, and the cell-structure of endocarp and seed, make the relationship to Icacinaceae indubitable, but we have been unable to discover its closer relationship. The form and sculpture both recall *Iodes*, but the absence of papillae on the locule-lining, and the occurrence of fibres over the surface of the testa, exclude it from the genus, so far as we have been able to examine recent material. Unfortunately, as we could study but few of the living genera microscopically, we were unable to discover the range of seeds in which a system of fibres is associated with the testa. That such a system may occur in the family is shown by *Gonocaryum* Miq., belonging to the section Icacineae (Engler). We have not, however, found it in any of those genera belonging to the sections Phytocreneae or Iodeae which we were able to examine in detail. Probably, therefore, the fossil does not belong to either of these two sections of the family.

V. 22702 Holotype, figured Pl. XVI, fig. 22. An endocarp.
V. 22703 Figured Pl. XVI, fig. 23. An endocarp, broken to show the seed and locule-lining.
V. 22704 An endocarp, broken slightly to show the seed.
V. 22705 An endocarp, small and somewhat distorted, now broken. It may belong to *I. ovalis*.
All the above are from the Bowerbank Coll., Sheppey.

Icacinicarya nodulifera n. sp.

PLATE XVI. figs. 24, 25.

DIAGNOSIS.—Endocarp oval or circular, somewhat compressed, surface nodular. Length, 14 mm.; breadth, 13 mm.; thickness, about 8 mm. Seed with testa formed of two coats, the outer coat of polygonal cells 0·05 to 0·1 mm. in diameter with shining black contents, the inner coat of square, oblong, or polygonal cells, 0·025 mm. in diameter.

HOLOTYPE.—V. 22706.

DESCRIPTION.—*Endocarp*: Oval or circular in outline, somewhat compressed so as to be lenticular in cross-section, bisymmetric, dehiscing into two equal valves. One-loculed, with a single pendulous seed. Surface ornamented with coarse rugosities separated from one another by furrows (Pl. XVI, fig. 25); there is a marked band of thickening over one lateral margin, associated with the funicle. This organ lies within the thickness of the endocarp wall, along one of the lateral margins; it turns inwards sharply at the apex, where it passes to the apical placenta (Pl. XVI, fig. 24). Endocarp formed of angular parenchyma. One of the innermost layers is formed of large, flat, equiaxial, conspicuously rayed and interlocking cells, 0·1 mm. in diameter, the rays approximating in length to the diameter of the undivided central area; another layer (perhaps the lining layer of the locule) is formed of small cells with sinuous interlocking margins. Length of an endocarp, 14 mm.; breadth, 13 mm.; estimated thickness, about 8 mm.

Seed: Conforming to the shape of the locule, lenticular, oval or circular in outline. Raphe median longitudinal on one of the broad surfaces. Hilum and chalaza not seen, but by inference from the evidence afforded by the raphe, terminal at opposite extremities. Testa formed of two coats. An outer coat one or two layers thick of large polygonal cells with shining black contents, 0·05 to 0·1 mm. in diameter. The raphe runs in the thickness of this coat, and there are also other branching fibres associated with it. An inner coat, formed of square, oblong, or polygonal cells, 0·025 mm. in diameter, such as are typical of the Icacinaceae. Length of a locule (and probably therefore of seed), 12 mm.; breadth, 10 mm.; thickness, 6 mm.

REMARKS.—Three specimens from Sheppey, and one from Herne Bay. The specimen taken as the holotype is much abraded and externally decayed; one valve only of the endocarp is preserved. It shows clearly the funicle, and the two coats of the testa. The specimen from Herne Bay has part of the endocarp preserved and shows the rugosities of the external surface clearly. It also shows the outer coat of the testa and the raphe. The two remaining specimens are locule-casts containing seeds.

AFFINITIES.—The anatomy and structure of these endocarps leave no doubt that they belong to Icacinaceae, but we do not know to which section of the family they should be referred. We have, therefore, placed them in the form-genus *Icacinicarya* under the name *I. nodulifera*.

In form and size the endocarps of *Icacinicarya nodulifera* somewhat resemble those of *Iodes eocenica* (p. 328), which differs in the more compressed form of its carpels, and in the surface being not nodular but formed of flattened or concave areas separated by ridges. Further, the locules of *Iodes eocenica* have a papillate lining, while the testa is formed of one layer of cells only, similar to those which form the inner seed-coat of *Icacinicarya nodulifera*.

V. 22706 Holotype, figured Pl. XVI, fig. 24. Half of an endocarp, the seed lying within. Both coats of the testa can be seen, and the funicle is also clear, lying in the thickness of the wall along one margin. The external surface of the endocarp is much abraded. *Bowerbank Coll.*, Sheppey.

V. 22707 Figured Pl. XVI, fig. 25. A seed with part of the endocarp (external surface fairly well preserved) attached to it. The seed shows the raphe in the outer coat of the testa. *D. J. Jenkins Coll.*, Herne Bay, 1930.

V. 22708 A locule-cast, partly broken to expose the seed within. *Bowerbank Coll.*, Sheppey.

V. 22709 A locule-cast, much abraded, fractured longitudinally to expose the much shrunken seed. The specimen probably belongs to *Icacinicarya nodulifera*. *Bowerbank Coll.*, Sheppey.

Icacinicarya foveolata n. sp.

PLATE XVI, figs. 26–28.

DIAGNOSIS.—Endocarp ovoid; length, 14 or 15 mm.; breadth, 11 mm.; thickness, 9 to 10 mm.; testa formed of two coats, the outer coat formed of large secreting hexagonal cells, often 0·1 mm. in diameter, the inner of square or polygonal cells, 0·025 mm. in diameter.

HOLOTYPE.—V. 22710.

DESCRIPTION.—*Endocarp:* One-loculed, one-seeded, ovoid, dehiscing into two equal valves, surface (as preserved) smooth, formed of small hexagonal cells of uniform size, which give a finely tessellated appearance. Styler canal conspicuous, terminal at the apex. Endocarp wall thick, formed of irregular digitate or sinuous cells. Length of endocarp, 14 to 15 mm.; breadth, 11 mm.; thickness, 9 to 10 mm.

Seed: Ovoid, conforming in shape to the locule, anatropous, as shown by the broad flat sinuous longitudinal raphe which extends the length of the seed; consequently the hilum and chalaza, although they have not been seen, must lie at opposite ends of the seed. Testa formed of two coats. The outer, with which the raphe is associated, is formed of large hexagonal cells with glistening black contents. They form a honeycomb pattern over the surface, except near the raphe where they are smaller and elongate. They vary in size in one part and another, the largest being 0·1 mm. in diameter. The inner layer of the testa is formed of small square or angular cells about 0·025 mm. in diameter such as are typical of the Icacinaceae. Length of locule (virtually of seed), 10 to 11·2 mm.; breadth, 8 to 9 mm.; thickness, 6 mm.

AFFINITIES.—Two specimens. Although many characters such as the tendency to split into symmetric halves, the cell-structure of the endocarp, and of the inner layer of the testa are typical of the Icacinaceae, yet at first we doubted whether it could belong to the family for we knew no members of it, either fossil or recent, in which the outer layer of the testa was formed of large secreting cells (a character which had at first suggested a possible alliance with the Lauraceae). Yet later we found the same character in the fossil species *I. nodulifera* (p. 349), which undoubtedly must be referred to the family. Consequently, it appears probable that this may be a character of the living family which our limited observation has not permitted us to discover.

V. 22710 Holotype, figured Pl. XVI, figs. 26–28. A fruit, fractured to show the seed and raphe. *Bowerbank Coll.*, Sheppey.
V. 22711 An endocarp, fractured to establish its identity. *Reid & Chandler Coll.*, Minster, 1928.

Icacinicarya minima n. sp.

PLATE XVI, figs. 29–34.

DIAGNOSIS.—Endocarp sub-globular, or ovoid, smooth; locule-lining finely papillate. Length, 7·5 mm.; breadth, 6 mm.; thickness, 6 mm. Seed with quadrangular testa cells 0·016 mm. in diameter.

HOLOTYPE.—V. 22712.

DESCRIPTION.—*Endocarp:* Smooth, sub-globular or ovoid, sometimes depressed from apex to base (Pl. XVI, fig. 30), bisymmetric, dehiscing along the plane of symmetry into two valves. Funicle lateral, in the plane of symmetry, lying in a canal which extends from the base to the apical placenta, and forms a longitudinal ridge on the external surface of the endocarp, also a thick broad ridge or infold on the wall of the locule. Hence the locule-cast has a deep marginal depression on the funicle side and a rather sharp ridge marking the junction of the two valves on the opposite side (Pl. XVI, figs. 29, 31). Endocarp wall thick and close-textured, formed of small obscure cells which give place to digitate, interlocking cells in passing inwards towards the locule. Around the funicle the cells are large, elongate and aligned longitudinally, the lining of the funicular canal is smooth, and is formed of elongate digitate cells also aligned longitudinally. Immediately outside the locule lining there is a smooth layer made up of highly characteristic cells, at least 0·1 mm. in diameter, with very long interlocking digitations. Locule-lining finely papillate, the papillae being about 0·025 mm. in diameter. Seed solitary. Length of most perfect carpel, 7·5 mm.; breadth in plane of symmetry, 6 mm.; thickness, 6 mm.

Seed: Conforming to the shape of the locule; chalaza circular (0·3 mm. in diameter), sub-terminal at that end of the seed which adjoins the base of the locule. Testa formed of quadrangular cells which measure about 0·016 mm. in diameter and are arranged radially around the chalaza. Length of locule (virtually of seed), 4·5 mm.; breadth in the plane of symmetry, 3·5 mm.; thickness at right angles to the plane of symmetry, 4·5 mm. In two other specimens the dimensions were as follows: Length, 6 mm.; breadth, 5·5 mm.; thickness, 5 mm.; and length, 6 mm.; breadth, 5 mm.; thickness, 5·5 mm.

REMARKS AND AFFINITIES.—Seventeen specimens. We at first experienced great difficulty in distinguishing this species from *Tetracera* (p. 400), but with increased experience, and careful study of cell-structures, we ultimately found it possible to discriminate between them, the resemblance being largely due to similarity of form. There can be no doubt that the fruits just described belong to the Icacinaceae, but we know no living genus which shows small, smooth, sub-globular endocarps almost as broad as long.

The endocarps of the fossil *Faboidea crassicutis* (p. 341) are smooth, and broader than long, with papillate locule-linings, but they are flattened. Hence *Icacinicarya minima* differs from *Faboidea* in the greater inflation of its endocarps, which results in a more globular form, also in the breadth being slightly less than the length, and in the dimensions being much smaller.

V. 22712 Holotype, figured Pl. XVI, fig. 29. An abraded endocarp, showing the funicle.
V. 22713 Figured Pl. XVI, figs. 30, 31. A locule-cast (somewhat distorted), showing the depression associated with the funicle. The cast is slightly chipped and shows the seed-cast inside. A film of endocarp adheres to the surface of the cast.
V. 22714 Figured Pl. XVI, figs. 32, 33. An abraded endocarp, showing remains of the funicle and the cast of the papillate locule-lining. The specimen also shows a peculiar asymmetry of form which sometimes occurs in this species. The specimen was labelled by Ettingshausen "*Carpolithes* sp. 4 (?)."
V. 22715 Figured Pl. XVI, fig. 34. A locule-cast with remains of the endocarp wall. The cast has been chipped away so as to expose the somewhat shrunken seed (figured). The chalaza is clearly seen on the seed.
V. 22716 Cast of an undistorted locule, showing the groove associated with the funicle. Remains of the endocarp wall adhere all over the surface.
V. 22717 Cast of a relatively large locule.
V. 22718 An abraded endocarp fractured to show the seed-cast inside.
V. 22719 Ten specimens; five are fractured, all are much abraded; one shows the seed-cast.

All are from the Bowerbank Coll., Sheppey.

Icacinicarya Jenkinsi n. sp.

PLATE XVI, figs. 35, 36.

DIAGNOSIS.—Endocarp slenderly oval, compressed; surface of locule raised into rounded prominences which are evenly spaced around the margins, papillate. Length, 10·5 mm.; breadth, 5·6 mm.; thickness, 2·5 mm.

HOLOTYPE.—V. 22720.

DESCRIPTION.—*Endocarp:* Compressed, slenderly oval in outline, surface of locule ornamented with about thirty large, round prominences (deep round pits on the internal cast of the locule) and further with evenly spaced small papillae (which form small pits in the cast) measuring 0·025 mm. in diameter. Around the margin of the locule the protuberances are evenly spaced and regularly arranged. The locule is rather sharply angular at its margins, and one face has a low, rounded, median longitudinal angle. Length of locule-cast, 10·5 mm.; breadth, 5·6 mm.; thickness, 2·5 mm.

Affinities.—The specimen is the perfect internal cast of a locule showing the characters described above. The evidence as to the tubercled and papillate surface of the locule, combined with the size and shape of the specimen is sufficient to refer it to the Icacinaceae. Therefore, we have not fractured it in order to discover whether a seed were present with the highly characteristic testa associated with the family.

The fossil differs from the endocarps of any other London Clay species of Icacinaceae in the character of the prominences which occur on the surface of the locule in association with papillae. Whether the prominences are or are not connected with the external sculpture of the endocarp we cannot tell, since this is not preserved. In size, but not in shape or number, they may be compared with the prominences on the locules of *Palaeophytocrene*. But they are much fewer, shallower, and with more gently rounded contours; also there is no regular marginal arrangement of the protuberances in *Palaeophytocrene* such as is seen in *Icacinicarya Jenkinsi* (Pl. XVI, fig. 36). Moreover, the locules of *Palaeophytocrene* are not papillate. In *Iodes*, papillate locules occur, but the external hollows of the endocarp are scarcely impressed on to the locule surface. Consequently the locule-casts show only obscure undulations. Whilst, therefore, the evidence for inclusion in the family Icacinaceae is clear, we cannot say to what living genus the fossil is most nearly allied. Hence we have referred it to the form-genus *Icacinicarya*.

V. 22720 Holotype, figured Pl. XVI, figs. 35, 36. A locule-cast. *D. J. Jenkins Coll.*, Herne Bay, 1930.

Icacinicarya (*Iodes ?*) *elegans* (Bowerbank)

1840. *Leguminosites elegans* Bowerbank (pars), p. 126, pl. xvii, fig. 6.

Bowerbank bases this species, which he compares with Leguminosae, on two different specimens. There can be no doubt that the one represented in his pl. xvii, fig. 6, belongs to the Icacinaceae. For although the type is now missing, Sowerby's beautiful drawing gives sufficient evidence to establish the relationship.

Bowerbank's diagnosis is as follows: "*Seed* edgeways subovate, sideways oblong, obtuse: radicle conspicuous, situated above the middle of the face of the seed: testa smooth: hilum inconspicuous." In view of the relationship to Icacinaceae now recognized, the terms used above must be interpreted as follows: "radicle" of Bowerbank = placenta; "face" = apex; "seed" = endocarp; "testa" = endocarp-wall.

The apex of the endocarp shows a characteristic knob-like protuberance on each side of the style; these represent the pyrites infilling of two short canals in the endocarp wall. The lower portion of the figure shows the thickened margin which is commonly associated with the lateral funicle in Icacinaceae. The specimen was obviously an endocarp in which the funicle and placental area had been partially exposed by abrasion. Bowerbank's description is very brief and he does not mention the characters which we have found to be of diagnostic value in discriminating genera and species within the family. His brevity probably means that the distinctive characters of cell-structure were obscure in these fossils, for usually he described such details very fully if they were preserved. In the London Clay Icacinaceae obscurity of cell-structure is common. It is then rarely possible to determine the genus or species, unless the characteristics are so well known to the investigator as to be recognizable even in small patches, or unless the material is sufficiently abundant to permit of fracturing and dissection. It is not impossible that *Iodes corniculata* (p. 323) should be referred to Bowerbank's species. But in the absence of the type, and of any knowledge of the structural details mentioned above, there is no evidence on which to establish such a conjecture. The names *Icacinicarya elegans* and *Iodes corniculata* must therefore be retained as possibly marking two distinct species.

[The second specimen which Bowerbank includes in *Leguminosites elegans* (his pl. xvii, figs. 5 and 7) is still extant, although it is no longer perfect. It may belong to the Icacinaceae, but it is quite distinct from the specimen in fig. 6. It is merely the cast of a locule and shows no structure at all; neither do Sowerby's figures show any definite characters to indicate its relationship.

V. 22721 Figured by Bowerbank (1840, pl. xvii, figs. 5, 7). A locule-cast, now broken. Indeterminable. *Bowerbank Coll.*, Sheppey.]

Icacinicarya rotundata (Bowerbank)

1840. *Leguminosites rotundatus* Bowerbank, p. 127, pl. xvii, figs. 8, 9.

Bowerbank's diagnosis of this species is as follows: "*Seed* sideways nearly circular, edgeways somewhat ovate: hilum minute, situated at about the middle of the face of the seed." And in his description he states that he has seen "but three of this species." "The thickness of the seed is very nearly equal to its depth from face to back, and its depth is nearly as great as its length." This description implies that the fossil is nearly globular and as such it is depicted.

We should not venture to comment on the species, because the type specimen has disappeared, were it not that we have found two specimens in the Bowerbank Collection similar to the one depicted on his pl. xvii, figs. 8, 9. They are much abraded locule-casts. One shows a layer of coarse digitate cells, at least 0·1 mm. in diameter, near the interior of the film of endocarp which remains on the locule-cast. It also shows the small polygonal or quadrangular cells of the testa (0·025 mm. in diameter) in a place where the locule-cast is broken away. The position of the placenta in this specimen corresponds with that of the small apical knob depicted in Bowerbank's fig. 8; and the placenta is of similar appearance. It seems, therefore, probable that the mark which Bowerbank regarded as the minute hilum is accidental.

The fossil which we have described above resembles *I. minima* in size, and it must certainly be referred to the Icacinaceae. It differs from *I. minima* in having no ridge on the wall of the locule associated with the funicle, and hence in having no corresponding groove on the locule-cast.

V. 22722–23 Two locule-casts. One shows digitate cells belonging to the endocarp, and it also shows the cells of the testa where the locule-cast is chipped away. *Bowerbank Coll.*, Sheppey.

Icacinicarya bognorensis n. sp.

Plate XVI, figs. 37, 38.

Diagnosis.—Locule-cast sub-globular; locule-lining formed of digitate cells, not papillate. Length, 4 mm.; breadth, 3·5 mm.; thickness, 3·6 mm. Seed with inflated quadrangular testa cells 0·025 mm. in diameter.

Holotype.—V. 22724.

Description.—*Endocarp* (represented by a locule-cast with a film of the endocarp adhering): Very small sub-globular, bisymmetric (as shown by a marginal ridge on one side), placenta (represented by a scar) marginal, apical, in line with the ridge, adjacent to the style (also represented by a scar); locule-lining showing clawed interlocking cells. Length of locule-cast, 4 mm.; breadth, 3·5 mm.; thickness, 3·6 mm.

Seed (not completely seen): Testa formed of inflated quadrangular cells measuring about 0·025 mm. in diameter.

Remarks.—The species is represented by a single locule-cast, in calcite, to which a film of the endocarp adheres; this shows in parts the actual cells, but in other parts only their impressions. The ridge which marks the bisymmetry is best seen near the two scars which mark the placenta and style, that is at the apex. It dies out below. Close to the placenta the locule-cast is broken. It shows within a cast of the seed, on the surface of which are the impressions of inflated quadrangular cells such as frequently form the testa in species of Icacinaceae, a family which, as we have seen, is common in the London Clay. Whilst, therefore, the Bognor endocarp clearly belongs to the Icacinaceae, it is much smaller and more globular than any found in the London Clay of Sheppey. Probably it is a distinct species; but except for size and form, no other distinctive specific characters have been preserved. We should not have distinguished it by a specific name, were it not that so few plants of any kind are known from the Bognor Rock; therefore it is desirable to give it a name in order to arrest attention.

The specimen was found in the Bognor Rock, Bognor, Sussex. It, and two specimens of *Vitis bognorensis* (p. 382), are the only fruits at present known from the Bognor Rock.

V. 22724 Holotype, figured Pl. XVI, figs. 37, 38. A calcite locule-cast. *E. M. Venables Coll.*, Bognor Rock, Bognor, 1929.

Icacinicarya sp. 11

Plate XVI, fig. 39.

Description.—*Endocarp*: Large, smooth, woody, one-seeded, oboval or roundly quadrangular, somewhat compressed, with basal attachment and lateral funicle, passing within the thickness of the wall to the apex, where it broadens and turns abruptly in to the locule to form the apical placenta. Endocarp formed of compact parenchymatous cells which sometimes appear to have interlocking digitate or sinuous outlines. Length, 18 mm.; breadth, 25 mm.; thickness, 15 mm.

AFFINITIES.—One broken endocarp; seed not seen. The specimen is much worn and in consequence the funicle is exposed in the upper part of its course, and around the placenta. The species is larger and relatively broader than any other fossil member of the family. The character of the endocarp and the position of the funicle leave no doubt as to its relationship to Icacinaceae, but, owing to the limited amount of material available for study, its characters are too little known to enable us to give it a specific name. For the same reason we are unable to assign it to any genus or section of the family.

V. 22725 Figured Pl. XVI, fig. 39. An endocarp, broken. *Bowerbank Coll.*, Sheppey.

Icacinicarya sp. 12

PLATE XVI, figs. 40, 41.

An endocarp, showing the characteristic ridged margin of Icacinaceae, is similar in its oval form and in its size to some of the smaller nuts referred to the family. It is ornamented with irregular, somewhat nodular, raised ribs. One of the lateral margins, thanks to abrasion, also shows the groove for the funicle, and the characteristic interlocking digitate cells can be seen lining the endocarp.

Whilst the available evidence is such as to place the specimen in the family beyond a doubt, it is insufficient to make comparison either with living or fossil species of any value, although the specimen appears to be distinct from any species previously described. Length of nut, 7 mm.; breadth, 5·6 mm.; thickness, 5·3 mm.

V. 22726 Figured Pl. XVI, figs. 40, 41. An endocarp, now fractured. *Bowerbank Coll.*, Sheppey.

Icacinaceae Incertae Sedis spp.

(1) 1879. *Salisburia eocenica* Ettingshausen, p. 393.
1883. *Ginkgo (?) eocenica* (Ettingshausen) Gardner, p. 46, pl. ix, figs. 31–34.
1919. *Ginkgo (?) eocenica* (Ettingshausen): Seward, pp. 32, 33.

Gardner figured two entirely pyritized, irregularly ovate specimens. He says that they are sharply keeled, the keel being sinuous, and the specimens being asymmetrical in consequence, but his figures and the extant specimen belie this description, for they show very distinct bisymmetry. He states that they are variable in form, "the largest measure some eleven millimètres in height by about nine millimètres in breadth, but they are occasionally wider than high, and more or less compressed, varying from seven to barely four millimètres in thickness." They are perfectly smooth, and Gardner supposed them to be internal casts of *Ginkgo* nuts. At one extremity he described a small truncated portion which he compared with that seen in the living *Ginkgo* seed. At the other extremity he described a trace of what he took to be a scar of attachment, which he supposed might indicate a leguminous origin. The specimens resemble *Ginkgo* in form, but are smaller and more sharply keeled than the seeds of that plant.

One of Gardner's figured specimens (V. 22727) is still extant in the British Museum. Careful examination shows it to be a locule-cast of some member of the family Icacinaceae. It is much abraded and poorly preserved, but it shows the characteristic pitted surface due to a papillate locule-lining. The "truncated portion" at the extremity is the cast of the inner termination of the funicle, and marks the placenta; an accretion of pyrites has accumulated around it giving the appearance of a small knob. The second figured specimen has disappeared.

The specimens had been previously listed by Ettingshausen in his provisional list of London Clay fossils (1879, p. 393) under the name *Salisburia eocenica* Ett. & Gard. Although there can be no doubt that the available nut should be referred to Icacinaceae, its condition is such that it cannot be related to any of the better preserved material described above, nor can it be described adequately as a distinct species.

On pp. 32, 33, vol. iv, of his work on Fossil Plants, Professor Seward says of these specimens that they "are smaller than the seeds of recent species, but in shape and in the keeled shell there is a fairly close resemblance. The hard sclerotesta forms the surface of the fossils. . . ." The specimens, he adds, do not "possess any interest as records of *Ginkgoites* seeds."

V. 22727 Figured by Gardner (1883, pl. ix, figs. 33, 34). A locule-cast. *Bowerbank Coll.*, Sheppey.

(2) Three lenticular casts preserved in decayed structureless pyrites were labelled "*Leguminosites* Bowerb." by Ettingshausen. One of them was broken transversely, but showed no structure. One was found to be composed of structureless pyrites throughout, but the third showed patches of the characteristic testa-cells of the Icacinaceae. All probably belong to the family Icacinaceae but not to the same species (or genus ?). All are quite indeterminable. There is no evidence to suggest relationship with Leguminosae, nor is there any reason for assigning them to any of Bowerbank's species of *Leguminosites*.

V. 22728 Three locule-casts, labelled by Ettingshausen "*Leguminosites* Bowerb." *Bowerbank Coll.*, Sheppey.

(3) A small, almost circular, compressed specimen was labelled "*Amygdalus* sp. n. 2" by Ettingshausen. It is too badly broken and decayed for description, but it shows the characteristic testa of Icacinaceae with angular inflated cells, and outside it the remains of a layer of coarse inflated cells representing either the locule-lining or a second coat of the testa. Length of specimen, 10 mm.

V. 22729 A small cast of a seed of Icacinaceae, now badly broken and decayed, labelled by Ettingshausen "*Amygdalus* sp. n. 2." *Bowerbank Coll.*, Sheppey.

Family ICACINACEAE ?

Genus ?

Plate XVI, figs. 42, 43.

The internal cast of an ovoid endocarp appears to belong to the Icacinaceae. At one end of the cast a small portion of the endocarp adheres and this shows large, interlocking, digitate cells such as occur in the endocarps of many genera in the family. Portions of the specimen from which the structureless pyrites of the locule-cast has gone, show within it the impression of the testa which is formed of inflated, angular, or oblong, cells (about 0·025 mm. in diameter), such as characterize the testa of many Icacinaceae. We should have no hesitation in referring this specimen to the family but for the fact that one end is somewhat truncated and has three deep depressions separated by ray-like ridges (Pl. XVI, fig. 43). They appear to represent the impression of three radially arranged elevations. Some of the Icacinaceae have apical placentas projecting into the locule, but we have seen none that is three-rayed. The form of the internal cast suggests that one seed only was developed and the surface of this seed seems to share in the triradiate depressions.

V. 22730 Figured Pl. XVI, figs. 42, 43. An internal cast of a seed with adherent remains of the locule-cast. *Bowerbank Coll.*, Sheppey.

Family SAPINDACEAE

Several genera and species referable to Sapindaceae occur in the London Clay. They are usually represented by seeds, but, not infrequently, by fruits also. The testa may be preserved either wholly or in part.

The embryos in this family are highly characteristic. The curved, tapering radicle, sometimes large, sometimes small, is contained in a pocket of the testa. The large cotyledons may lie upon or beside one another, and be without folds; or they may lie upon one another and be folded or coiled together in a more or less complicated manner. The embryo, which is exalbuminous, completely fills the seed, and its superficial characters are impressed more or less distinctly on the inner surface of the testa. The form of the radicle is always clear, for this is delimited by the pocket of the testa. The superficial form and the lines of curvature of the two cotyledons are not always so clearly seen, for the lines of demarcation between the two cotyledons and the impressions of their folds may not be distinctly impressed on the testa. Hence it follows that internal casts of the seed may show on their surface, more or less clearly, the form of the radicle and cotyledons, although the embryo itself has disappeared.

In the living Sapindaceae certain facts in regard to the embryos can be observed:—

(1) Similar types of radicle and cotyledons may occur in more than one genus.

(2) Individuals are remarkably true to specific type.

The first fact implies that occasionally it is difficult, and it may be impossible, to determine between different genera from the seeds and embryo alone; although were the whole living range of species available, and were it possible to make close microscopic study of these organs, the difficulty might be overcome.

The second implies that individuals can be classified according to type, with the probability that, when the resemblance between them is very close, they may be also classified according to species; and the practical certainty that, when the characters are in any great degree peculiar, the classification will be truly specific.

With regard to the fossils, it must be remembered that London Clay genera are to a very large extent extinct. Therefore, we should expect to meet, among the Sapindaceae, a large proportion of extinct genera. Hence in this family, in which extremely close comparison of the embryos is necessary in any attempt to distinguish between the various genera, the absence of material for such comparison, whether it be due to extinction in the past, or want of living material in the present, makes the task of relating the fossils to living genera for the most part prohibitive. In a few cases where the form of radicle is very clear and the folding of the cotyledons very peculiar and distinctive, as in *Palaeallophylus* n. gen., the generic connexion seems so definite that we have given a name which implies living relationship ; but the name must be restricted to a peculiar type of embryo having the well-defined characters described. In other cases, where a type of embryo occurs in which one cotyledon lies upon another without any folding, a type very common in the living family, we have grouped the different forms as species, under the comprehensive genus *Sapindospermum*, thereby indicating family but not generic relationship.

Genus PALAEALLOPHYLUS nov.

DIAGNOSIS.—Seeds referable to Sapindaceae, hilar scar gibbous, cotyledons coiled together, each being also transversely folded upon itself ; distinguished from the seeds of *Allophylus* by having the fold of the inner cotyledon rotated from the hypocotyl through an angle greater than 90°.

GENOTYPE.—*Palaeallophylus ovoideus* n. sp.

DISCUSSION.—Two species referable to the family Sapindaceae show a peculiarity in the form of their embryos which appears to us to indicate that they belong to a single genus. This peculiar character is the sharp transverse folding of both the coiled cotyledons upon themselves.

We made a careful study of the embryos of various genera in Kew Herbarium, so far as material permitted, in many cases more than one species in a genus being examined. But only in one genus, *Allophylus* Linn., were we able to find both of the coiled cotyledons sharply folded upon themselves as in the fossil. At the same time there is a marked difference between the living and fossil embryos in the relative positions of the transverse folds with regard to the hypocotyl. In three species of *Allophylus* which we were able to study, *A. ternatus* Forst., *A. cobbe* Bl., *A. africanus* Beauv., the transverse fold of the inner cotyledon is rotated from the hypocotyl through an angle of from 30° to 40° (text-fig. 9*a*). In the fossil species *P. ovoideus* it is rotated through an angle of about 100° (text-fig. 9*c*), and in *P. rotundatus* through an angle of about 140° (text-fig. 9*d*). But we must observe that we have only seen six out of the ninety or more living species, and it is possible that some of those not seen may show a greater degree of rotation. In the absence of more complete information it has seemed desirable to place the fossils in a distinct genus, which we have named *Palaeallophylus*.

The living genus *Allophylus* inhabits the tropics and sub-tropics of the whole world. Those species in which we have seen the embryo folded as in the fossil are natives either of Asia or Africa.

Palaeallophylus ovoideus n. sp.

PLATE XVII, figs. 1–7; text-figs 9*c*, 10*a*, *b*.

1879. *Victoria Sheppyensis* Ettingshausen, p. 395.

DIAGNOSIS.—Seed ovoid; fold of inner cotyledon rotated from the hypocotyl through an angle of about 100°; chalazal band narrow and parallel-sided; radicle long and thick.

HOLOTYPE.—V. 22731.

DESCRIPTION.—*Seed:* Ovoid. Hilar scar a large gibbous area against which the radicle abuts. The micropyle lies near the middle of the straight (or slightly

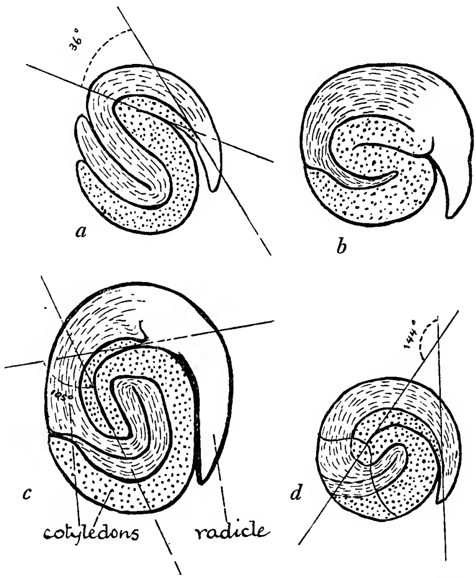


FIG. 9.—Diagrammatic figures of some fossil and recent sapindaceous embryos to show the folding of the cotyledons. The angle of rotation of the proximal fold of the inner cotyledon from the hypocotyl is indicated. *a*, *Allophylus*, recent; *b*, *Cardiospermum*, recent; *c*, *Palaeallophylus ovoideus*; *d*, *Palaeallophylus rotundatus*.

convex) margin of this scar. The hilum also is median near the convex margin (Pl. XVII, fig. 1, text-fig. 10*a*). The raphe enters the testa at the hilum and passes gradually through its thickness, along a median plane, to the chalaza, which is marked by a transverse band on the interior of the testa at some little distance from the convex margin of the hilar scar (Pl. XVII, figs. 5, 6, text-fig. 10*b*). The testa (much worn) is fairly thick and formed externally of cells with a columnar arrangement which are preserved in small patches only. Within this columnar coat is a carbonaceous coat of parenchyma several cells thick, which is succeeded by a thin inner carbonaceous layer of fine parenchyma. The " embryo " (cast of seed-cavity) shows a finely striate surface formed of delicate cells arranged so that they diverge from the chalaza and are aligned longitudinally over the radicle. These striations are somewhat obscured by the superimposed impression of the cells of the fine parenchyma which lies immediately outside them. The cotyledons are large and coiled, each being also sharply folded transversely upon itself. The fold of the inner cotyledon is rotated through an angle of about 100° from the hypocotyl (text-fig. 9*c*). The outer cotyledon is slightly auricled at the hypocotyl. The radicle is long and thick, broadening very gradually and uniformly to the hypocotyl (Pl. XVII, figs. 4, 5, text-fig. 10*b*). The diameter of the seed in one specimen measured from the hilum was 10 mm. ; diameter from the radicle to the chalaza, 9 mm. ; diameter of the " embryo " measured from the hilum, 9 mm. ; measured from the radicle to the

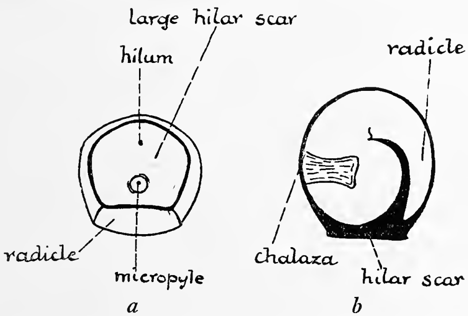


FIG. 10.—*Palaeallophylus ovoideus*. *a*, base of seed showing hilar scar (diagrammatic) ; *b*, diagrammatic side view of seed from which the testa has been removed, showing the radicle and chalaza.

chalaza, 8 mm. ; a second specimen, diameter of " embryo " measured from hilum, 8 mm. ; from radicle to chalaza, 6 mm. ; a third specimen, diameter of seed measured from hilum, 8·5 mm. ; diameter of " embryo " from hilum, 5·5 mm.

REMARKS.—About a hundred specimens, usually represented by casts of the seed-cavity in structureless pyrites. Although many have fragments of testa adhering, the external columnar coat is but rarely preserved, even in patches. The closer textured inner coat of parenchyma apparently tends to be freed by decay from the thick outer coat, as there is frequently a layer of mud filling a space between the two. No delicate fibrous layer has been seen between the two coats (cf. *P. rotundatus*, p. 362), but this is probably due to the mode of preservation which differs in different specimens even of the same species. In a few specimens the hilar scar has evidently broken away, the gap left by its removal being occupied by a mass of crystalline pyrites embedded in the surrounding testa.

AFFINITIES.—The characteristic form of the embryo affords indubitable evidence that these seeds belong to the family Sapindaceae. The relationship to *Allophylus* has already been discussed (p. 359).

V. 22731 Holotype, figured Pl. XVII, fig. 1. A seed with much of the testa preserved. The hilar scar is clearly seen.
[The seed figured Pl. XVII, fig. 2, has now completely decayed.]

V. 22732 Figured Pl. XVII, fig. 3. A seed, fractured longitudinally to show the internal cast (virtually the embryo) separated from the testa by a wide intervening space filled with pyrites. Only a thin film of testa remains on the surface of the pyrites.

V. 22733 Figured Pl. XVII, fig. 4. A seed-cast (" embryo "), showing the large radicle still partially embedded in the adherent inner coat of the testa.

V. 22734 Figured Pl. XVII, fig. 5. A seed-cast (" embryo "), with remains of the inner layers of the testa still clinging around the radicle. The specimen shows the strap-shaped chalaza very clearly.

V. 22735 Figured Pl. XVII, fig. 6. A seed-cast (" embryo "), showing the chalaza-scar clearly.

V. 22736 Figured Pl. XVII, fig. 7. A seed-cast (" embryo "), showing the impressions of the folded cotyledons.

V. 22737 About eighty specimens and many fragments. The specimens are, in the main, internal casts of seeds; many have the tip of the radicle broken. They were formerly in jars, two of which were labelled " *Victoria Sheppyensis* sp. n. Bowerbank Collection," while V. 22731, –32, –34, and some others, were in a jar labelled " *Sabal* sp." by Ettingshausen.
All the above are from the Bowerbank Coll., Sheppey.

V. 22738 An internal cast of a seed. *Reid & Chandler Coll.*, Eastchurch.

V. 22739 Ten seed-casts in various states of preservation. *Reid & Chandler Coll.*, Minster.

Palaeallophylus rotundatus n. sp.

Plate XVII, figs. 8–12, text-fig. 9*d*.

Diagnosis.—Seed globular; fold of inner cotyledon rotated from the hypocotyl through an angle of 140°; chalazal band not parallel-sided, broad, occupying about one-quarter of the circumference; radicle slender and tapering.

Holotype.—V. 22740.

Description.—*Seed:* Globular. Hilar scar gibbous, smaller than that of *P. ovoideus*, with the micropyle near the straight margin and the raphe passing into the testa near the convex margin. The chalaza is seen as a transverse band on the interior of the testa occupying a segment of about 90°. Testa thick, much worn externally so that the outermost columnar coat is almost entirely worn away, the thick inner coat of coarse parenchyma being therefore exposed on the surface. Within the coarse coat is a layer of fine fibres which radiate from the hilum, and within that again, a second coat of fine parenchyma, too decayed for accurate description; it forms the pocket in which the radicle lies. The cast of the seed-cavity shows on its surface delicate striations; these radiate from the large chalaza, situated approximately opposite the hypocotyl (Pl. XVII, fig. 10, text-fig. 9*d*.), and over the radical are directed longitudinally. Embryo with large coiled cotyledons, each folded transversely upon itself, the fold of the inner cotyledon being rotated from the hypocotyl through an angle of about 140°. Radicle shorter than in *P. ovoideus*, slender and tapering, but broadening rather suddenly behind the hypocotyle (Pl. XVII, figs. 10, 12, text-fig. 9*d*). Diameters of seed, 11 and 13 mm.; diameter of " embryo ", 6·5 mm. measured from the hilum; 7 mm. measured from radicle to chalaza.

Affinities.—One specimen only, with part of the worn testa preserved. The thick outer parenchymatous layer was carbonized, but strongly impregnated with pyrites. In order to study the convolutions of the embryo the testa was completely removed, after photographing the seed, so as to expose the cast of the seed-cavity. The impressions of the radicle and cotyledons on this cast showed clearly the relationship to *Allophylus* and to *Palaeallophylus ovoideus* (cf. pp. 359, 360).

The species differs from *P. ovoideus* in its globular instead of ovoid form ; in its smaller size ; in its smaller, shorter, more slender but suddenly expanding radicle ; in its smaller hilum ; in the angle of rotation of the cotyledons ; and in the thicker testa.

V. 22740 Holotype, figured Pl. XVII, figs. 8–12. A seed with remains of its testa, now broken away to show the character of the cotyledons and radicle. *Bowerbank Coll.*, Sheppey.

Genus PALAEALECTRYON nov.

Diagnosis.—Seed ovate in outline, laterally compressed ; hilar scar small ; radicle short ; cotyledons spirally coiled, the outer through an angle of 360°, the inner through an angle of 540° ; greatest diameter, 13·5 mm.

Genotype.—*P. spirale* n. sp.

Palaealectryon spirale n. sp.

Plate XVII, figs. 13–19, text-fig. 11.

Diagnosis.—That of the genus.

Holotype.—V. 22741.

Description.—*Seed :* Ovate, laterally compressed. Hilar scar rather obscure, but relatively small, and gibbous. Testa fairly thick, formed of four coats : (1) The outer one is formed of small polygonal or quadrate cells which give a finely punctate outer surface to the seed. (2) Within is a coat formed of several layers of large irregular cells variously aligned so as to give a tortuous and tangled appearance. (3) Next is a fibrous coat several cells thick. (4) The innermost coat lining the seed-cavity is formed of fine, close, fusiform or elongate polygonal cells which give rise to a smooth finely striate surface. Embryo large, coiled spirally, radicle short and triangular ; the outer cotyledon is coiled in a complete circle, 360°. The inner cotyledon is coiled through 540°. A curved groove runs across the flat surfaces of the internal cast of the seed, as clearly shown in Pl. XVII, figs. 15, 16, and in text-fig. 11. It separates a dull area, which may be associated with the chalaza, from a shining area of pyrites. A transverse band at the lower extremity of the dull area may mark the actual chalaza scar. Greatest diameter in plane of symmetry, 13·5 mm. ; least diameter in same plane, 9·5 mm. ; thickness, 7·5 mm.

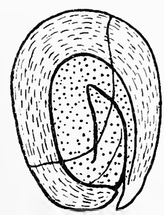


Fig. 11. — *Palaealectryon spirale.* Seed with testa removed (diagrammatic), showing the folding of the cotyledons.

Remarks.—Two seeds with part of the testa adhering. One specimen shows very clearly large strands of branching and anastomosing fibres which run from the hilum within the testa (Pl. XVII, fig. 19). The other shows a layer of fine criss-cross fibres, the ultimate network to which the large fibres eventually give rise. It also shows very clearly the chalaza, the radicle and the curving of the cotyledons (Pl. XVII, figs. 13–18; cf. also text-fig. 11).

AFFINITIES.—Spirally coiled embryos occur in various genera of Sapindaceae, the degree of coiling differing greatly. Seeds which in size, shape, and form of cotyledon resemble the fossil occur in the genus *Alectryon*. In them the cotyledons are thin as in the fossil and are coiled in the same way and to much the same degree. In *A. carinatus* Radlk. the outer cotyledon is curved through 360° and the inner through 720°. In *A. connatus* Radlk. both cotyledons are curved through 330°. The cotyledons of *Atalaya variifolia* F. Müll. show a comparable degree of curvature, but in this genus are always thick, thus differing from the fossil.

Alectryon is a genus of tall trees which inhabits the Malayan regions, New Guinea, New Caledonia, Australia, and New Zealand.

V. 22741 Holotype, figured Pl. XVII, figs. 13–18. An internal cast of a seed with fragmentary remains of the testa (detached). The specimen shows very clearly the curving of the cotyledons and the form of the radicle. The tip of the radicle was broken, but was placed in position for photographing.

V. 22742 Figured Pl. XVII, fig. 19. An internal cast of a seed, with remains of the testa showing fibres.

V. 22743 Half an internal cast of a seed.

All are from the Bowerbank Coll., Sheppey.

Genus CUPANOIDES Bowerbank emend.

1840. Fossil Fruits and Seeds of London Clay, p. 65.

DIAGNOSIS.—Fruit syncarpous three- or four-loculed, formed of three or four carpels, dehiscing loculicidally; seeds solitary in each locule, erect; embryo curved; radicle folded on to the cotyledons, dorsal, directed downwards. A form-genus for species referable to the section Cupanieae, of which the nearer relationship cannot be determined.

Since Bowerbank studied the London Clay fossils, the genera *Cupania* Linn. and *Ratonia* D.C. have been subjected to revision by Radlkofer. His work resulted in a division of the two original genera into many closely allied ones, unfortunately based on parts of the plant which are not found fossil in the London Clay. Whether such divisions can be recognized in every case from their fruits and seeds, we cannot tell, owing to lack of living material for comparison. Partly on this account, and partly because those species and genera which we have seen frequently possess fruits which are very difficult to distinguish from one another, we cannot be sure of the exact relationship between the fossils named *Cupanoides* and living forms. Consequently, whilst stating what appears to be the nearest relationship, we have deemed it inadvisable to refer the fossils definitely to existing genera. It may be noted in passing, that the alliance is with Old World genera, so far as we have been able to trace it.

Another cause of uncertainty as to the exact affinities of the species of *Cupanoides* described below lies in our ignorance of the form of the fossil embryos. Thus in

Cupanoides grandis Bowerbank, although the position of the radicle and cotyledons can be seen, their precise form cannot, and in *Cupanoides tumidus* Bowerbank the form of the cotyledons is unknown. This lack of information introduces a further element of difficulty into the more precise determination of these fossils.

Bowerbank originally described eight species of *Cupanoides* differentiated by their forms. Our study of living material shows that much of the variation which he regarded as specific is really individual. At the same time, he overlooked a real difference between two groups of specimens in the structure of the pericarp, which is associated with slight differences in form, and appears to us to be of specific, if not of generic significance. We have consequently reduced Bowerbank's eight species to two, *Cupanoides tumidus,* including *C. inflatus,* and *C. grandis,* including all Bowerbank's remaining species. These two species belong in all probability to distinct genera, but we have nevertheless left them in the form-genus *Cupanoides* Bowerbank for reasons stated above. The diagnosis given by Bowerbank (1840, p. 65) is as follows: "*Capsule* superior, three-celled, three-valved, and three-seeded; dehiscence loculicidal. *Seed* erect, face straight: testa woolly. *Placenta* central, triangular." His description includes the following statements: "the epicarp is thin and membranaceous, the sarcocarp more or less pulpy or fleshy, and the endocarp membranaceous, somewhat like paper in its texture, and frequently presenting the appearance of a series of wrinkled lines. These lines, originating at the placenta, pass off towards the exterior of the pericarp in an ascending direction. . . ." The "seeds" which Bowerbank goes on to describe, are in reality the internal casts of the locules, not the seeds proper. The sub-basal "hilum" of his description is, therefore, equivalent to the placenta, while his "central triangular" placenta is merely the axial part of the fruit. He further states that "When the testa [lining of the endocarp] is viewed with a power of eighty linear, it is seen to be coated with a very fine thickly-set pile or down, the direction of the fibres of which is from the face towards the back of the seed." This apparent hairiness is in reality due to decay and disruption of the fibres which form the endocarp, not to the presence of a hairy testa or locule-lining. He did not see the true seed.

A specimen of the genus, which should probably be referred to *C. grandis,* was figured by Parsons (1757, pl. xvi, fig. 5). He suggested tentatively that it might be a *Euonymus.* The figure was reproduced by Pennant (1801, pl. opp. p. 88, fig. 5). The same specimen, apparently, was drawn by Crow in his manuscript catalogue (1810, No. 74), while he illustrated a four-loculed specimen in his No. 575.

A specimen of *Cupanoides,* species uncertain, was figured by Sowerby (1809, pl. 300, top row, right-hand figure). He compared it with *Thea viridis, Euphorbia,* and *Menispermum.*

Fruits from Sheppey, evidently referable to *Cupanoides,* were described, but not figured, by Adolphe Brongniart (1828, p. 130) under the name *Amonocarpum.* He compared them with *Amonum* [*Amomum*] though he regarded the relationship to this genus as doubtful. Bowerbank subsequently showed such a relationship to be out of the question (1840, p. 68), and in 1849 (pp. 83, 92) Brongniart accepted Bowerbank's determination.

Cupanoides tumidus Bowerbank

Plate XVII, figs. 20–22.

1840. *Cupanoides tumidus* Bowerbank, p. 72, pl. xi, figs. 13–17.
1840. *Cupanoides inflatus* Bowerbank, p. 73, pl. xi, figs. 18–22.
1850. *Cupanoides tumidus* Bowerbank: Unger, p. 458.
1850. *Cupanoides inflatus* Bowerbank: Unger, p. 458.
1852*a*. *Cupanoides tumidus* Bowerbank: Massalongo, p. 26.
1852*a*. *Cupanoides inflatus* Bowerbank: Massalongo, p. 27.
1874. *Cupanoides tumidus* Bowerbank: Schimper, p. 173.
1874. *Cupanoides inflatus* Bowerbank: Schimper, p. 173.
1879. *Cupania tumida* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania inflata* (Bowerbank) Ettingshausen, p. 395.
1888. *Cupanoides tumidus* Bowerbank: Schenk, p. 548, fig. 312,[4], [5].
1888. *Cupanoides inflatus* Bowerbank: Schenk, p. 548, fig. 312[6].
•1928. *Cupanoides inflatus* Bowerbank: Edwards & Wonnacott, p. 28.
1928. *Cupanoides tumidus* Bowerbank: Edwards & Wonnacott, p. 29.

Diagnosis.—Fruit globose, surface rough with small tubercles; cells of pericarp radially directed and with narrow strands of tangentially aligned cells; locule-lining finely striate, rugose. Length, 15 mm.; diameter, 14 mm.

Holotype.—V. 22744.

Description.—*Fruit:* A three- or four-loculed globose capsule, dehiscing loculicidally by the removal of large valves which fall away from a fibrous axis. The axis forms a scar or tumidity at the base of the fruit (cf. Bowerbank, 1840, pl. xi, fig. 18). Each valve has a slight, shallow, longitudinal, median depression on its external surface. External surface of fruit rough with small tubercles. Carpel wall formed of rather long cells directed radially, between which are narrow strands, about two cells wide, of small tangentially directed cells; the wall is traversed towards the periphery by longitudinal branching and anastomosing strands of fibres. Locule-lining finely striate transversely and having an undulating, somewhat rugose surface (Pl. XVII, fig. 21). The pyrites locule-casts, figured as "seeds" by Bowerbank, were described by him as of a "mytiloid form." Length of fruit, 15 mm.; breadth, 14 mm.

Seed: Solitary in the locule. Erect, somewhat laterally compressed, with the embryo folded upon itself as in many species of Sapindaceae. Testa rather thin, finely striate externally (but the surface cell-structure too obscure for accurate description), in section showing a columnar arrangement of cells; part of the testa projects between the radicle and cotyledons so as to form a pocket enclosing the radicle. Cotyledons large and curved, their exact limits and their relationship to one another not seen, owing to the fact that the embryo is only known from a rather imperfect internal cast of the testa; radicle large, tapering, terete, external (Pl. XVII, fig. 22). Length of seed, 5 mm.; breadth, 3·5 mm.

Remarks.—The specimen figured Pl. XVII, fig. 20, is Bowerbank's type, and his only specimen of *C. tumidus* (Bowerbank, 1840, pl. xi, figs. 13–17). The type of *C. inflatus* Bowerbank (1840, pl. xi, figs. 20, 22) is also extant (two valves only), and as we can see no distinction of specific value between them, we have treated *C. inflatus* as a synonym for *C. tumidus*. It is evident that the minute distinctions on which

Bowerbank based *C. tumidus* and *C. inflatus* are not of specific rank. They indicate rather slight differences of the form of the capsule, and of the locule. His figures of *C. inflatus* should be inverted, as it is clear from his description of this fossil, and from our own comparison with the type, that he mistook the apex for the base.

In addition to the above-mentioned types, there are also four other specimens and some fragments, one specimen being represented by three complete valves, and the other three by two valves with possibly a fragment of a third. All are preserved in the same way, the carpel wall being partially carbonized and the locule being occupied by a structureless pyrites cast which may or may not enclose the remains of a seed. A few such casts had been fractured dorsi-ventrally when they reached us so as to expose the seed, represented by a pyrites cast of the testa. The description given above incorporates Bowerbank's general conclusions and many of his valuable observations, but differs in some important respects from his account, because as stated above, the " seed " in his description is really the locule-cast (Bowerbank, 1840, p. 74, pl. xi, figs. 5, 6) and the " nucleus " is the true seed (*loc. cit.*, pl. xi, figs. 20, 21, 22).

Affinities.—The evidence afforded by the form of this fruit, and by the form and structure of the seed, place it without a doubt in the family Sapindaceae, whilst, as Bowerbank recognized, the particular size, form, and mode of dehiscence place it in near relationship to *Cupania*, a relationship which is supported by the arrangement of the seed in the locule, the form of the radicle and the curvature of the cotyledons. In the section Cupanieae, under which Radlkofer distributes the genera formerly classed as *Cupania* and *Ratonia*, certain species of the genus *Guioa* Cavanilles (natives of the Malay Peninsula, the Philippines, New Guinea, New Caledonia, and Australia) closely resemble *C. tumidus*. Thus *G. nervosa* F. von Mueller (Queensland) has a capsule, identical in size and shape with the fossil, and has a warty external surface. The capsule is neither stipitate nor ribbed ; the valves are shed completely. Unfortunately the seeds of this species were not seen, but other species, *e.g. G. Perrottii* Radlk., have embryos which agree in structure with that of the fossil so far as this is known. The genus *Elattostachys* also has similar fruits, but those seeds which we have seen have a thin and narrow radicle which does not reach and partially embrace the base, *e.g. E. xylocarpa* Radlk., *E. incisa* Radlk. The genus *Guioa* therefore seems to be the most closely comparable living type, but the evidence in regard to the embryo of the fossil is insufficient to justify a reference to the living genus.

V. 22744 Holotype, figured Pl. XVII, fig. 20. Also figured by Bowerbank 1840, pl. xi, figs. 13–17. A capsule, which has now dehisced into three valves. This is the only specimen referred by Bowerbank to *C. tumidus*.

V. 22745 Figured Pl. XVII, fig. 21. A capsule, two valves only preserved, which has dehisced to show the internal cast of the locule.

V. 22746 Figured Pl. XVII, fig. 22. A capsule, two valves only preserved, it shows a locule-cast fractured so as to expose the internal cast of the seed (virtually the embryo) within.

V. 22747 A capsule, two valves only preserved. This specimen is the type of *Cupanoides inflatus* Bowerbank and is figured by him (1840, pl. xi, figs. 18–22), but the valve represented in fig. 21 is now missing.

V. 22748 A capsule, which has now dehisced into three valves. One of the valves is broken transversely.

V. 22749 A capsule, represented by two and a half valves now detached. The locule-cast inside has fractured longitudinally so as to expose within the cast of a shrivelled and abortive seed.

V. 22750 Five broken valves of fruits.

All are from the Bowerbank Coll., Sheppey. All but V. 22744 must have been regarded by Bowerbank as *C. inflatus*, as he states that he had only one specimen of *C. tumidus*.

Cupanoides grandis Bowerbank

PLATE XVII, figs. 23–33; text-fig. 12.

1840. *Cupanoides grandis* Bowerbank, p. 71, pl. xi, figs. 10–12.
1840. *Cupanoides lobatus* Bowerbank, p. 69, pl. xi, figs. 1, 2.
1840. *Cupanoides corrugatus* Bowerbank, p. 69, pl. xi, figs. 3, 4.
1840. *Cupanoides subangulatus* Bowerbank, p. 70, pl. xi, figs. 7–9.
1840. *Cupanoides depressus* Bowerbank, p. 74, pl. xi, fig. 23.
1840. *Cupanoides pygmaeus* Bowerbank, p. 75, pl. xi, fig. 24.
1844. *Cupanoides lobatus* Bowerbank: Mantell, p. 179, fig. 43 (5).
1850. *Cupanoides grandis* Bowerbank: Unger, p. 458.
1850. *Cupanoides lobatus* Bowerbank: Unger, p. 457.
1850. *Cupanoides corrugatus* Bowerbank: Unger, p. 458.
1850. *Cupanoides subangulatus* Bowerbank: Unger, p. 458.
1850. *Cupanoides depressus* Bowerbank: Unger, p. 458.
1850. *Cupanoides pygmaeus* Bowerbank: Unger, p. 459.
1852*a*. *Cupanoides grandis* Bowerbank: Massalongo, p. 26.
1852*a*. *Cupanoides lobatus* Bowerbank: Massalongo, p. 25.
1852*a*. *Cupanoides corrugatus* Bowerbank: Massalongo, p. 25.
1852*a*. *Cupanoides subangulatus* Bowerbank: Massalongo, p. 26.
1852*a*. *Cupanoides depressus* Bowerbank: Massalongo, p. 27.
1852*a*. *Cupanoides pygmaeus* Bowerbank: Massalongo, p. 27.
1874. *Cupanoides grandis* Bowerbank: Schimper, p. 173.
1874. *Cupanoides lobatus* Bowerbank: Schimper, p. 172.
1874. *Cupanoides corrugatus* Bowerbank: Schimper, p. 173.
1874. *Cupanoides subangulatus* Bowerbank: Schimper, p. 173.
1874. *Cupanoides depressus* Bowerbank: Schimper, p. 173.
1874. *Cupanoides pygmaeus* Bowerbank: Schimper, p. 173.
1879. *Cupania grandis* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania lobata* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania corrugata* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania subangulata* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania depressa* (Bowerbank) Ettingshausen, p. 395.
1879. *Cupania pygmaea* (Bowerbank) Ettingshausen, p. 395.
1888. *Cupanoides corrugatus* Bowerbank: Schenk, p. 548, fig. 312[3].
1928. *Cupanoides corrugatus* Bowerbank: Edwards & Wonnacott, p. 27.
1928. *Cupanoides depressus* Bowerbank: Edwards & Wonnacott, p. 27.
1928. *Cupanoides grandis* Bowerbank: Edwards & Wonnacott, p. 28.
1928. *Cupanoides lobatus* Bowerbank: Edwards & Wonnacott, p. 28.
1928. *Cupanoides pygmaeus* Bowerbank: Edwards & Wonnacott, p. 28.
1928. *Cupanoides subangulatus* Bowerbank: Edwards & Wonnacott, p. 29.

DIAGNOSIS.—Fruit roundly angled, or lobed, shortly stipitate, surface smooth; cells of pericarp radiating in small groups from many centres; locule-lining striate obliquely or transversely. Length from 12 to 20 mm.

HOLOTYPE.—V. 22751.

DESCRIPTION.—*Fruit:* Roundly triangular, occasionally quadrangular, or sometimes roundly three- or four-lobed, the lobing being more marked above (Pl. XVII, fig. 26), shortly stipitate (Pl. XVII, figs. 23, 25), syncarpous, usually three-loculed and three-seeded, rarely four-loculed and four-seeded, dehiscing loculicidally by three or four valves. Exocarp thick, formed of large prismatic cells arranged in irregular groups in which the cells tend to radiate from many centres (contrast with *C. tumidus*, p. 366); towards the periphery the cells more or less radiate outwards; longitudinal strands of fibres are embedded within the exocarp, and there are thick longitudinal strands of fibres along the angles of the fruit where loculicidal splitting occurs. Locule lined by a thick coat (several cells deep) of fibres directed obliquely or transversely, according to position, from the axis of the fruit. Placentas basal at the inner angles of the locule, on the axis. The dimensions of five specimens are given below: (1) Radius of fruit from axis, 6·5 mm.; length of fruit, 14 mm. (2) Radius, 10 mm.; length, 20 mm. (3) Radius, 8 mm.; length, 15 mm. (4) Radius, 8 mm.; length, 15 mm. (5) Radius, 6·25 mm.; length, 12 mm.

Seed: Compressed, sub-circular in outline with finely striate testa formed of two coats; an outer coat, 0·05 mm. thick, columnar in section, and an inner somewhat thinner coat of radially compressed cells. Embryo exalbuminous, spirally curved; radicle dorsal, inferior, terete, longitudinally striate, probably with a transverse constriction where the cotyledons arise; cotyledons folded upon themselves, the outer being coiled through 360° and completely encircling the inner, the exact form of which is not known (Pl. XVII, fig. 33; text-fig. 12). Length of seed, 4·5 mm.; breadth (dorsiventral), 4·5 mm.

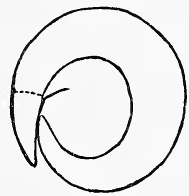


FIG. 12.—*Cupanoides grandis* Bowerbank. Seed with testa removed (diagrammatic) to show the form of the radicle and (in part) of the cotyledons. The folding of the inner cotyledon is obscure. The broken line indicates a probable transverse constriction or furrow on the radicle.

REMARKS.—Forty-five or more specimens. Some are abraded or have dehisced so as to show the pyritized locule-cast, the "seed" of Bowerbank, which tends to fall free from the fruit (Pl. XVII, figs. 27, 31, 32). The shape of the fruit depends to some extent on the degree of abrasion of the exocarp, the abraded specimens generally appearing to be more definitely lobed and angled than the less abraded specimens. A broken locule-cast shows the true seed lying within it (Pl. XVII, fig. 33). Two other specimens also show curved seeds which, although they cannot be freed from the matrix, afford the same evidence of a downward pointing dorsal radicle. A well-preserved but unripe specimen of a four-loculed fruit also belongs to this species (Pl. XVII, fig. 27). It shows the structure of the carpel fairly clearly, but is too highly pyritized for the seed to be isolated in a perfect condition. The broken seed, however, shows the form and position of the radicle.

One specimen only of Bowerbank's figured fruits (V. 22751) is now extant. It is therefore taken as the holotype, although it is now in a broken condition.

AFFINITIES.—All the characters of this species show that it also belongs to the section Cupanieae of the family Sapindaceae. *Elattostachys verrucosa* Radlk. has many characters in common with the fossil but is always more inflated. The genus *Cupaniopsis* (especially *C. anacardioides* Radlk.) bears the closest resemblance. The fruit is sharply angled and strongly fibrous along the angles (a fairly common feature in the family), the apex of the fruit is either elevated or depressed, the base is slightly stipitate, the surface is rough. The fibres at the angles of the capsule stop short of the base, their termination being marked by a notch, and the fruit only splits down to this point, the valves remaining attached to the axis, and to one another, below it. The interior of the valves is slightly woolly, but the hairs can be rubbed off with the greatest ease and the transversely striate lining is then exposed. The seed has a large, dorsal, inferior radicle.

Cupaniopsis is found along the river banks of the east coast of Australia, growing sometimes in salt water.

So far, however, as the embryonic structure of *Cupanoides grandis* is known, it does not agree with that of any living species of the section Cupanieae which we have been able to examine, including *Elattostachys* and *Cupaniopsis*.

Cupanoides grandis differs from *C. tumidus* chiefly in the arrangement of the cells forming the carpel wall. In *C. grandis*, as stated above, the large cells are grouped so as to radiate irregularly from numerous centres. In *C. tumidus* they all radiate outwards from the centre of the fruit and are divided by narrow strands of tangentially aligned cells. Unabraded specimens are usually less globose and more lobed in *C. grandis* than in *C. tumidus*, and the lobes are narrower and less rounded in the former than in the latter species.

V. 22751 Holotype, figured Bowerbank (1840, pl. xi, fig. 11). A capsule, fractured longitudinally (half only preserved) showing the locule-casts.
V. 22752 Figured Pl. XVII, figs. 23, 24. A small, probably abortive capsule showing the prominent apex.
V. 22753 Figured Pl. XVII, fig. 25. Similar capsule, showing a depressed apex.
V. 22754 Figured Pl. XVII, fig. 26. A small, but fairly well-developed capsule, figured to show the great tumidity below.
V. 22755 Figured Pl. XVII, fig. 27. A four-loculed fruit.
V. 22756 Figured Pl. XVII, fig. 28. A well-developed capsule, figured to show the base.
V. 22757 Figured Pl. XVII, fig. 29. A small capsule, figured to show the apex.
V. 22758 Figured Pl. XVII, fig. 30. A detached valve of a capsule.
V. 22759 Figured Pl. XVII, fig. 33. A broken valve of capsule and part of a locule-cast showing the embryo (seed-cast) within.
V. 22760 Parts of two dehisced fruits showing valves and locule-casts.
V. 22761 A fruit, represented by locule-casts, now broken.
V. 22762 A fruit, represented by locule-casts and a few fragments. One of the casts is fractured longitudinally and shows the remains of a seed within. The specimens were labelled "*Cupanoides grandis* Bow." in a copper-plate hand. The specimens figured Pl. XVII, figs. 31, 32, were originally with these, but they have now decayed.
V. 22763 A valve of a capsule.
V. 22764 Five fruits and a detached locule-cast in various states of preservation and development.
V. 22765 Twenty-four fruits and a few fragments in various states of preservation and development.
All the above are from the Bowerbank Coll., Sheppey.
V. 22766 A fruit, now broken. *Reid & Chandler Coll.*, Eastchurch, 1928.
V. 22767 Four small abraded fruits. *Reid & Chandler Coll.*, Minster, 1929.

Genus SAPINDOSPERMUM nov.

Diagnosis.—Seeds with curved embryos referable to Sapindaceae, which cannot be more definitely determined.

Sapindospermum ovoideum n. sp.

Plate XVIII, figs. 1–5.

Diagnosis.—Embryo ovoid; radicle more than half as long as the seed, broad; cotyledons fleshy, not coiled, superposed; transverse furrow at the base of the radicle curved; greatest diameter in the plane of symmetry, 13 mm.; diameter perpendicular to that plane, 8·5 mm.

Holotype.—V. 22768.

Description.—*Seed:* Ovoid, hilum oval, slightly truncate where the radicle abuts against it (Pl. XVIII, fig. 1); testa (preserved only in part) formed of coarse parenchyma, the innermost layer (seen on the internal cast of the seed-cavity) of fine, irregular polygonal cells. Embryo large, exalbuminous, radicle more than half the length of the seed, gradually tapering to a blunt rounded end which lies in a pocket of the testa (Pl. XVIII, figs. 2, 4); cotyledons thick and fleshy, not coiled, lying one upon the other (Pl. XVIII, figs. 3–5); hypocotyl (?) marked by a curved transverse furrow at the base of the radicle (Pl. XVIII, figs. 2–4). Greatest diameter of seed in plane of symmetry, 13 mm.; least diameter in same plane, 8·5 mm.; thickness at right angles to this plane, 9·5 mm.

Remarks.—One specimen, much abraded so that portions only of the pyritized testa remain. These adhere to a cast of the seed-cavity preserved in calcite which reproduces very clearly the form of the exalbuminous embryo. We removed the bulk of the testa so as to expose the casts of the cotyledonary lobes. Over the radicle it adhered firmly and could not be removed, but the size and shape of this organ were quite clearly indicated.

Affinities.—The form of the embryo places the fossil indubitably in the family Sapindaceae. The two living genera which, so far as we have seen, have the most closely comparable embryos are *Guioa* and *Cupaniopsis*, but the type of embryo is common, so that the evidence for definite reference to either of these genera is inadequate. *Guioa* is a genus of trees and shrubs inhabiting India, Further India, Malaya, the Philippines, Australia, and Polynesia. *Cupaniopsis* includes trees and shrubs of Australia and Polynesia.

V. 22768 Holotype, figured Pl. XVIII, figs. 1–5. A seed with remains of the testa. *D. J. Jenkins Coll.*, Herne Bay.

Sapindospermum Jenkinsi n. sp.

Plate XVIII, figs. 6–8.

Diagnosis.—Embryo ovoid; radicle half as long as the whole embryo, broad; cotyledons fleshy, not coiled, superposed; transverse furrow at the base of the radicle straight; greatest diameter in the plane of symmetry, 13·5 mm.; diameter perpendicular to that plane, 10·5 mm.

Holotype.—V. 22769.

Description.—*Seed:* Ovoid, testa abraded except a small fragment of the inner coat, which shows radially compressed polygonal cells; the lining of the seed-cavity (seen on the internal cast of the testa) is formed of small oblong cells which are longitudinally aligned over the radicle, where best preserved. Embryo large, exalbuminous; radicle (broken at the tip) about half as long as the seed, rather broad (Pl. XVIII, figs. 6, 8); cotyledons thick and fleshy, lying upon one another, the groove which delimits them being continued along the radicular end to the point at which this is broken; the upper cotyledon is delimited from the radicle by a transverse groove (Pl. XVIII, figs. 6, 8). Greatest diameter of the seed in the plane of symmetry, 13·5 mm.; least diameter in the same plane, 11 mm.; thickness at right angles to this plane, 10·5 mm.

Remarks and Affinities.—One specimen, a pyrites cast of a seed-cavity reproducing the form of the exalbuminous embryo. It is broken into three pieces and the tip of the radicle is abraded.

The form of the embryo places the specimen in the family Sapindaceae. It differs from *Sapindospermum ovoideum* in the somewhat larger size, and in the straight transverse groove delimiting the radicle from the upper cotyledon. Since *S. ovoideum* and the species just described were both derived from Herne Bay, we at first felt some doubt as to whether two such similar specimens could represent separate species. Reference to living material, however, suggests that the differences noted are probably specific, and we therefore describe the specimens under distinct specific names. Should further evidence at any time contradict this conclusion, it would then be an easy matter to combine the two.

V. 22769 Holotype, figured Pl. XVIII, figs. 6–8. A seed-cast. *D. J. Jenkins Coll.*, Herne Bay.

Sapindospermum grande n. sp.

Plate XVIII, figs. 9–11.

Diagnosis.—Embryo obovoid; radicle slender; greatest diameter in plane of symmetry, 20 mm.; diameter perpendicular to this plane, 15·3 mm.

Holotype.—V. 22770.

Description.—*Seed:* Obovoid, somewhat laterally compressed, and flattened on one side so as to be rather asymmetric. The asymmetry may indicate that it was one of two seeds developed in a locule. Hilar scar relatively small, obscure owing to incrusting structureless pyrites. Testa of three distinct coats; the outer of these is thick and formed of cells arranged in a columnar manner which give rise to a smooth, minutely punctate external surface; within there is a coat of coarse parenchyma in which are embedded many longitudinal fibres, radiating from a circular area at the end opposite to the hilum, over which the outer coat of the testa has broken away (Pl. XVIII, fig. 10). The area may mark the position of the chalaza, as fibres pass in towards the seed-cavity in this region. The innermost coat (as seen), preserved only in parts, is formed of a thin layer of columnar cells which also give a punctate surface; it forms the pocket for the radicle. Embryo curved, radicle tapering (Pl. XVIII, figs. 9, 11), length of radicle uncertain, because, as the limits of the cotyledons are not seen, it is doubtful where the base of the radicle lies. Greatest diameter of seed measured from the hilum, 20 mm.; breadth from radicle to opposite face, 14 mm.; thickness at right angles to the plane of symmetry, 15·3 mm.

REMARKS.—One seed, pyritized and with adherent nodules of amorphous pyrites. In parts the outer layers of the testa are broken away, but the pyritized inner coat firmly adheres over the whole surface, thereby obscuring the true internal cast of the seed-cavity and the form and limits of the cotyledons. An attempt to remove this inner coat so that the exact form of the embryo could be determined resulted in the fracture of the specimen, owing to the fact that it was merely a hollow shell of pyrites lining the seed-cavity, and not a solid cast.

AFFINITIES.—The relationship to the family Sapindaceae is clearly evidenced by the curved embryo with its characteristic radicle, but in the absence of more precise knowledge as to the form of the embryo it is impossible to determine the affinities more closely. The seed is very large, but not larger than the seeds of some living members of the family. It is distinguished both by its form and size from any other species described.

V. 22770 Holotype, figured Pl. XVIII, figs. 9–11. A seed with the testa imperfectly preserved; the cotyledons are not shown as the true internal cast of the testa is nowhere visible. *Bowerbank Coll.*, Sheppey.

Sapindospermum sp. 4

PLATE XVIII, figs. 12–14.

DESCRIPTION.—*Seed:* Small, oblong-ovoid, somewhat laterally compressed. Hilar scar gibbous with its straight margin abutting on the radicle. Testa almost completely abraded except near the hilar scar, finely pitted on its inner surface, structure otherwise obscure. Chalaza marked by a narrow transverse band not far from the convex margin of the hilar scar. Embryo curved, radicle rather short, tapering, its proximal end being marked by a pair of small auricles at the point of origin of the outer cotyledon (Pl. XVIII, fig. 14). Cotyledons obscurely folded together; the inner cotyledon may be coiled spirally; it does not seem to be transversely folded on itself (Pl. XVIII, figs. 12, 13). Length of seed in plane of symmetry, measured from the hilum, 7 mm.; breadth, 5 mm.

AFFINITIES.—One seed found by ourselves at Minster. The specimen is a cast in pyrites of the seed-cavity showing upon its surface the impressions of the inner pitted layer of the testa, and, very obscurely, the convolutions of the cotyledons. The hilar and chalazal regions are much obscured on the cast by the adherent remains of the pyritized testa. There can be no doubt that the seed belongs to the family Sapindaceae, and that it is distinguished by its size and shape, apparently also by the folding of the cotyledons, by the character of the small auricles on the outer cotyledon, and by the short radicle, from any other species found at Sheppey. Unfortunately, the exact mode of folding is so uncertain as to forbid any attempt to ascertain the generic relationship.

V. 22771 Figured Pl. XVIII, figs. 12–14. An internal cast of a seed. *Reid & Chandler Coll.*, Minster, 1929.

Genus ? (SAPINDACEAE)

PLATE XVIII, fig. 15.

DESCRIPTION.—*Fruit:* Syncarpous, multilocular, lobed, number of lobes uncertain but probably three, each lobe one-loculed and one- (or two- ?) seeded. Lobes attached for about half their length to a thick, straight axis from which they diverge at angles of about 50°, the upper third of the carpel being free. Locule-lining formed of several layers of fibres directed obliquely from the axis, the wall external to the lining being formed in part of fine parenchyma, of which but a very small portion remains. Greatest length of carpel in plane of symmetry, 14 mm.; breadth in same plane, 9 mm.; thickness at right angles to this plane, 7 mm.

Seed: Obscure, testa formed externally of small polygonal cells slightly inflated, embryo apparently curved.

REMARKS.—One specimen representing the internal cast of a locule, which bears on its surface the impression of the fibres that formed the lining layers. Fragments of the actual pyritized inner layers of fibres and parenchyma still cling in patches to the surface of this cast. The specimen was fractured, and showed, embedded in the pyrites, the shrunken and decayed remains of a curved seed, so placed that the plane of curvature passed symmetrically through the carpel and axis. Whether the radicle were dorsal or ventral could not be ascertained. The impression of the testa was preserved on one small surface of glistening pyrites and the hollow external impressions of the small polygonal cells indicated that these were slightly inflated in the original seed coat. A small amorphous mass of carbonaceous matter near this seed may perhaps represent an abortive seed, but this is quite uncertain. There is no evidence to show whether the fruit was capsular or not, neither is it possible to determine the original number of carpels, but the shape of the solitary extant carpel suggests that there were three united by their inner edges to the axis. The marked bisymmetry suggests loculicidal dehiscence.

AFFINITIES.—The form of the carpel, combined with that of the seed, leaves no doubt that the fossil should be referred to the family Sapindaceae. It may belong to the section Eusapindaceae with one seed in each locule, but even this is doubtful. The evidence available is insufficient to permit of comparison with any of the other fossil species which are known from seeds. The carpel differs in shape from those fossils of which the fruit is known.

V. 22772 Figured, Pl. XVIII, fig. 15. The internal cast of a locule. *Bowerbank Coll.*, Sheppey.

Sapindospermum ? subovatum (Bowerbank)

1840. *Leguminosites subovatus* Bowerbank, p. 125, pl. xvii, figs. 1, 2.
1879. *Leguminosites subovatus* Bowerbank: Ettingshausen, p. 396.

Bowerbank gives the following diagnosis of this species: "*Seed* subovate, thickness slightly exceeding half its length, depth from front to back exceeding three fourths of its length. *Embryo* near the middle of the face of the seed."

Except for a few details as to the proportions of this seed, there is little further information in the description beyond the statement that "The testa has suffered greatly from decomposition." And further that it "was thin and smooth," and that "all traces of the hilum have been obliterated." We have not seen the specimen, but the illustrations suggest most strongly that this seed is not leguminous but belongs to the Sapindaceae. The form of radicle seen in the engraving may occur in both families but, were it a leguminous seed, so careful a draughtsman as J. de C. Sowerby would certainly have indicated a perpendicular line beneath the free end of the radicle in fig. 1, marking the division between the cotyledons. Moreover, the outward curve of the line marking the left-hand proximal end of the radicle in fig. 1 more resembles the curve of the radicle in Sapindaceae than in Leguminosae.

Family SABIACEAE

Genus MELIOSMA Blume

1823. Cat. Gew. Buitenz., 10.

Meliosma Jenkinsi n. sp.

PLATE XVIII, figs. 16–23; text-fig. 13.

DIAGNOSIS.—Endocarp ovoid, somewhat laterally compressed; funicular canal perpendicular to the ventral face; dorsi-ventral diameter, from 8·5 to 10·5 mm.; greatest diameter in plane of symmetry (at right angles to the last measurement), from 9 mm. to 13 mm.; greatest diameter at right angles to plane of symmetry, from 7·5 to 10 mm.

HOLOTYPE.—V. 22773.

DESCRIPTION.—*Endocarp*: One-loculed, ovoid, somewhat laterally compressed, bisymmetric about a plane which includes the two major axes; the margin where this plane cuts the carpel is angled (Pl. XVIII, fig. 18) except on the ventral face. This face is pierced by a large deep funnel-shaped opening, the funicular canal, passing directly, not obliquely, into the locule; it has smooth down-sloping sides formed by the incurved ventral wall of the endocarp (Pl. XVIII, fig. 22). The opening is closed by a plug of coarse-celled tissue (Pl. XVIII, fig. 23) through which the vascular strands of the funicle pass to the placenta, which lies immediately beneath the orifice. Walls of the endocarp thick (about 0·8 mm.), formed of woody parenchyma; locule-lining formed of centipede-shaped cells with interlocking digitations (text-fig. 13). These cells are arranged radially around the orifice, where they are relatively short and broad; elsewhere they may be 0·15 mm. long, and 0·05 mm. broad. Measurements of three specimens show: greatest dorsi-ventral diameter, 10·5 mm., 10 mm., 8·5 mm.; greatest length in plane of symmetry, perpendicular to the last measurement, 10 mm., 13 mm., 9 mm.; greatest breadth at right angles to the plane of symmetry, 9·5 mm., 10 mm., 7·5 mm.

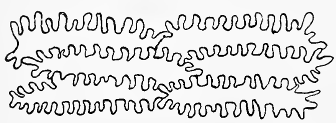


FIG. 13.—Diagrammatic figure of cells lining the endocarp of a *Meliosma*.

Seed: Solitary, conforming to the shape of the locule, convex and angled on the dorsal surface, concave on the ventral surface. Hilum and chalaza ventral, marked by a conspicuous thickening of the testa, which in this region is fused with the plug of loose tissue. The testa is more or less adherent to the endocarp and shows two coats—an outer close striate coat, formed of fusiform cells which radiate from the plug; and an inner coarse irregular and reticulate coat of loose tissue, the cells of which vary from 0·025 mm. to 0·1 mm. in diameter.

REMARKS.—Six specimens. They show a tendency for the plug to break away with the incurved wall of the endocarp adhering to it (Pl. XVIII, figs. 16, 17, 19, 20, 22). When thus fractured the ventral side of the seed lies exposed (Pl. XVIII, fig. 19). In one specimen, the testa came away as a thin plate from this ventral side, thereby revealing the internal cast of the seed (ventral surface) with the chalazal scar (Pl. XVIII, fig. 21). The seed has sometimes shrunk and partially collapsed so that it does not completely fill the locule (Pl. XVIII, fig. 22).

AFFINITIES.—The structure and anatomy both of endocarp and seed are those of *Meliosma*. In form, and in the direct ventral canal, the endocarp resembles *M. Veitchiorum* Hemsley and *M. Beaniana* Rehd. & Wils.; though these are almost always smaller, but one specimen of *M. Veitchiorum* from Yunnan (Forrest 12766), which closely resembles the fossil in shape, measures 9 mm. along its greatest diameter and is as large as the smallest of the fossil specimens. *M. lanceolata* Blume measures 11 mm. and is similar in shape to the fossil. *M. nitida* Bl., which differs in shape, measures 14 mm. Clearly, therefore, *Meliosma Jenkinsi* lies well within the limit of size of living species.

Meliosma is a genus of trees and shrubs chiefly inhabiting the tropics and sub-tropics of eastern Asia. *M. lanceolata* and *M. nitida* are found in the dense jungles of Java, Sumatra and Borneo; *M. Veitchiorum* and *M. Beaniana* are natives of China. A few species also occur in the West Indies, Central America, and tropical South America, but the New World species do not resemble the London Clay fossils so closely as do those of the Old World.

V. 22773 Holotype, figured Pl. XVIII, figs. 16–21. A well-preserved locule-cast with remains of the endocarp on the ventral side, fractured to show the seed and chalaza. *Bowerbank Coll.*, Sheppey.

V. 22774 Figured Pl. XVIII, fig. 22. Half a large endocarp, showing the thick carpel wall, the plug, and the shrunken and contracted seed. *Bowerbank Coll.*, Sheppey.

V. 22775 Figured Pl. XVIII, fig. 23. A worn specimen, simulating a palm seed, mainly internal cast of endocarp, showing the large plug and aperture for the fibro-vascular cords. *Reid & Chandler Coll.*, Minster, 1929.

V. 22776 Two distorted locule-casts, one fractured to show the plug. *Reid & Chandler Coll.*, Minster, 1929.

V. 22777 A locule-cast, fractured longitudinally. *D. J. Jenkins Coll.*, Herne Bay.

Meliosma cantiensis n. sp.

PLATE XVIII, figs. 24–30.

DIAGNOSIS.—Endocarp sub-ovoid, stylar end bluntly beaked; funicular cavity oblique to the ventral face. Corresponding measurements to those given in *M. Jenkinsi*, 3·5 to 5·5 mm.; 5 to 8 mm.; 4·5 to 8 mm.

HOLOTYPE.—V. 22778.

DESCRIPTION.—*Endocarp:* One-loculed, sub-ovoid, bisymmetric about a dorsi-ventral plane through the ventral attachment; angled in the plane of symmetry except on the ventral side, where the angle dies out at one end in a sub-terminal beak-like prominence, and gives place at the other end to a wide shallow depression (Pl. XVIII, fig. 24). Dorsal surface hemispherical, ventral surface concave, owing to the incurving of the endocarp wall to form the funicular canal which leads obliquely into the locule (Pl. XVIII, figs. 24, 26, 30). The canal is closed by a wedge-shaped plug of parenchyma through which the vascular strands of the funicle pass to the placenta on the ventral wall of the locule beneath the orifice. Endocarp thick, formed of fine woody parenchyma, the locule-lining being composed of elongate centipede-shaped cells, the walls of which have interlocking digitations at right angles to the long axes of the cells (cf. text-fig. 13). These lining cells diverge obliquely from the median line. Some are very large, measuring 0·3 mm. in length and 0·1 mm. in breadth. Four endocarps show the following measurements. Dorsi-ventral diameter 3·5, 5·5, 4·5, 4·5 mm.; greatest length in plane of symmetry, perpendicular to the last, 5, 8, 6·5, 6 mm.; breadth perpendicular to plane of symmetry, 4·5, 8, 6, and 5 mm.

Seed: Solitary, convex on the dorsal side, concave on the ventral, the ventral face being sub-cordiform in outline. Hilum and chalaza ventral, closely associated with the plug of the endocarp. Cells of testa elongate, about 0·01 mm. broad, with thickened lateral walls giving a striate appearance; the striae run longitudinally over the dorsal surface, but over the ventral surface they radiate from the hilum and chalaza.

REMARKS.—Thirty-five endocarps from Sheppey and three seed-casts from Herne Bay. The endocarps vary considerably in size and shape in accordance with the degree of abrasion. Most of the specimens are locule-casts in which the endocarp has been reduced to a mere film, while in some specimens it is completely worn away, the pyritized cast of the locule, or even of the seed, alone remaining. Only within the ventral hollow where the plug and an infilling of pyrites afford protection from abrasion, is the complete thickness of the endocarp wall preserved. The structure and form of the plug and of the incurved ventral wall were ascertained by fracturing one or two specimens. The ventral face of the locule-cast is much more emarginate in outline than the endocarp itself (cf. Pl. XVIII, figs. 24, 26).

AFFINITIES.—The structure and anatomy of the fossils are those of *Meliosma*. The locule-lining of centipede-shaped cells is highly characteristic of the genus; we have found similar cells in every living species that we have examined. The testa cells of the fossil are also similar to those of living species, but are somewhat larger. *M. Beaniana* Rehd. & Wilson, *M. Ridleyi* King, and *M. Veitchiorum* Hemsl. are comparable in external form, but the endocarps of *M. Ridleyi* are deeper than the fossils; those of *M. Veitchiorum* perhaps show the closest superficial agreement. But in all these species there is a direct ventral canal and plug, not an oblique one, as in the fossil. On the other hand, *M. pungens* Wall. and *M. Oldhami* Miquel, although distinctly different in external form, are like the fossil in the obliquity of the ventral hollow and plug. Hence the peculiar characteristics of *M. cantiensis* can all be found within the genus *Meliosma,* although apparently they are not combined in any one living species.

The present-day distribution of the genus is given above in the account of *M. Jenkinsi,* as is also the distribution of the two species *M. Beaniana* and *M. Veitchiorum.* *M. Ridleyi* is a plant of Malay, *M. pungens* of the Himalayan region and Japan, *M. Oldhami* of Japan.

V. 22778 Holotype, figured Pl. XVIII, figs. 24, 25. A small endocarp with carpel wall much abraded.
V. 22779 Figured Pl. XVIII, figs. 26, 27. A large endocarp, internal cast.
V. 22780 Figured Pl. XVIII, fig. 28. A locule-cast with remains of the carpel wall, showing clearly the interlocking cells.
V. 22781 Figured Pl. XVIII, figs. 29, 30. An endocarp and seed-cast, fractured longitudinally to show the funicular aperture and plug in the ventral wall.
V. 22782 An internal cast of a seed.
All the above are from the Bowerbank Coll., Sheppey.
V. 22783 Thirty endocarps in different stages of abrasion. *Reid & Chandler Coll.,* Minster, 1929.
V. 22784 Three seed-casts, probably referable to this species. *D. J. Jenkins Coll.,* Herne Bay.

Meliosma sheppeyensis n. sp.

PLATE XVIII, figs. 31–33.

DIAGNOSIS.—Endocarp sub-globose, angled at the stylar end; funicular cavity oblique to the ventral face; corresponding measurements to those given in *M. Jenkinsi* 3·5 to 4 mm.; 3 to 4 mm.; 3 to 3·5 mm.

HOLOTYPE.—V. 22785.

DESCRIPTION.—*Endocarp:* One-loculed, sub-globular, bisymmetric about a plane through the ventral attachment and style; at the stylar end the two sides meet at an angle in the plane of symmetry to form a rounded prominence; but the angle dies out towards the middle of the dorsal surface, or else is continued very obscurely to the ventral margin at the opposite end to the style. Dorsal surface highly convex; ventral surface somewhat flattened, and roundly incurved at its centre to form the small, deep, circular funicular canal, through which the vascular strands of the funicle pass to the placenta. The opening, which is somewhat oblique, is filled by a loose plug of parenchyma (Pl. XVIII, fig. 33). Endocarp walls thick and composed of rather coarse woody parenchyma, the innermost layer, constituting the locule-lining, being formed of elongate centipede-shaped cells with interlocking digitations; over the dorsal surface these cells are aligned more or less longitudinally. The measurements of three specimens show: dorsi-ventral length, 4 mm., 3·5 mm., 4 mm.; greatest diameter in plane of symmetry (perpendicular to the last measurement), 4 mm., 3 mm., 4 mm.; greatest diameter perpendicular to plane of symmetry, 3·5 mm., 3 mm., 3·3 mm.

Seed: Solitary, conforming to the shape of the locule. Surface seen only in one small patch where a minute fragment of pyritized testa shows small obscure cells.

REMARKS.—Three endocarps, all perfect and with the endocarp wall preserved except on one small patch of the dorsal surface of each specimen where it had been worn away. From one of these patches which showed cell-structure, a further small fragment was chipped away showing the characteristic centipede-shaped cells which line the locule in species of *Meliosma*. Another fruit was fractured longitudinally; it then showed the form of the oblique ventral canal and again the characteristic cells of the locule-lining.

AFFINITIES.—There can be no doubt at all that these beautiful little specimens are the fruits of a species of *Meliosma*. They are well within the limits of size of the genus, agreeing with the smaller species in that respect. The endocarps of the recent *M. cuneifolia* Franch., from Tibet, are considerably smaller. For the distribution of the genus, see p. 376.

V. 22785 Holotype, figured Pl. XVIII, figs. 31, 32. An endocarp with carpel wall preserved although much polished by abrasion.
V. 22786 Figured Pl. XVIII, fig. 33. An endocarp, somewhat abraded, fractured longitudinally to show the character of the ventral aperture and canal.
V. 22787 A small, slightly distorted endocarp.
All are Reid & Chandler Coll., Minster, 1929.

Family VITACEAE

Genus VITIS (Tourn.) Linnaeus

1737. Gen., ed. i, p. 56.

Vitis subglobosa n. sp.

PLATE XVIII, figs. 34–37.

DIAGNOSIS.—Seed sub-globose, with smooth contours, scarcely pointed at the base, neither flattened nor depressed at the apex; chalaza nearly median, small, round, with a median groove below it; ventral infolds of the testa broad, short, concave to the raphe ridge; raphe ridge on ventral face broad, broader above than below, sulcus for the raphe at the apex wanting; length from hilum, 5 mm.; breadth transverse to plane of symmetry, 5 mm.; thickness in plane of symmetry, 2·6 mm.; thickness of testa, 0·5 mm.

HOLOTYPE.—V. 22788.

DESCRIPTION.—*Seed:* Sub-globose, with smooth and rounded contours, scarcely pointed at the base, and neither flattened nor depressed at the apex. Ventral face with two short, broad, longitudinal infolds of the testa (one each side of the raphe ridge) which are rather wide apart, especially at their upper ends, and are slightly concave towards the raphe ridge (Pl. XVIII, fig. 35). The infolds extend only about half the length of the ventral face. Raphe ridge very wide, broadening in the middle of its course, and wider at its upper than at its lower end. Dorsal face (Pl. XVIII, fig. 34) with a small round chalaza, below which it has a well-marked median groove (deep, on the internal cast, Pl. XVIII, fig. 36); there is no median groove between the chalaza and the apex except on the cast. Testa thick in proportion to the size of the seed, formed of cells arranged in a columnar manner, the ends of which give a pitted internal surface, the pits varying from 0·016 to 0·025 mm.

in diameter. Tegmen formed of fine polygonal cells 0·015 to 0·016 mm. in diameter. Length of seed, 5 mm.; breadth, 5 mm.; thickness (in plane of symmetry), 2·6 mm.; thickness of testa, about 0·5 mm.

REMARKS.—Two seeds. One is perfect except that the testa is fractured over a small portion of the dorsal surface. But the fracture has the advantage of showing the testa in section. The testa has also come away from the chalazal-scar, giving the appearance at first sight of a very deeply sunk chalaza. The seed (Pl. XVIII, figs. 34, 35) has undergone considerable distortion by compression from base to apex.

The second seed was found at Herne Bay. It is not distorted, but has undergone much abrasion so that the testa is almost worn away, and the cast within is exposed. In consequence, the ventral ruminations and chalazal area appear larger than in the other specimen in which the testa, being more or less intact, partially fills them. Although it is thus imperfect, this specimen gives a better idea of the true contours of the seed, because of its undistorted condition (Pl. XVIII, figs. 36, 37).

AFFINITIES.—This vine probably belongs to the section Euvitis of the genus *Vitis*. *V. aestivalis* Michx., a native of the southern part of North America, is similar in character and of the same size but is rather more inflated, and its ventral infolds are deeper, straighter, and less concave to the raphe ridge. It has a groove for the raphe between the chalaza and apex on the dorsal surface which does not occur in the fossil.

V. 22788 Holotype, figured Pl. XVIII, figs. 34, 35. A seed with much of the testa preserved. The specimen is somewhat distorted; the testa is broken away on the dorsal surface near the base and over the chalaza. *Reid & Chandler Coll.*, Minster, 1929.

V. 22789 Figured Pl. XVIII, figs. 36, 37. A seed, internal cast. *D. J. Jenkins Coll.*, Herne Bay, 1929.

Vitis semenlabruscoides n. sp.

PLATE XIX, figs. 1, 2.

DIAGNOSIS.—Seed obovate with smooth contours, roundly triangular in section, slightly stipitate; chalaza nearly median, small, round, and shallow with a slight groove below; ventral infolds straight (?); apical sulcus for raphe wanting; length from hilum, 4 mm.; breadth perpendicular to plane of symmetry, 3·5 mm.; thickness in plane of symmetry, 2·5 mm.

HOLOTYPE.—V. 22790.

DESCRIPTION.—*Seed:* Small, obovate, with smooth rounded contours, and slightly stipitate base. It is roundly triangular in section, the dorsal face being convex and the ventral face faceted, the facets meeting at an angle of about 90°. The ridge thus formed carries the raphe; it can only be traced near the base and apex, the middle part being obscured by the adherent remains of the placenta and associated pyrites. The longitudinal infolds which flank this ridge are obscured by the same remains, but appear to be straight (Pl. XIX, fig. 2). The raphe passes over the apex to the dorsal face along a slight flattening of the surface, but there is no well marked groove or canal. The chalaza lies about the middle of the dorsal face; it is small, shallow, and round, and a slight groove is continued to the base of the dorsal face (Pl. XIX, fig. 1). Length of seed, 4 mm.; breadth, 3·5 mm.; thickness in plane of symmetry, 2·5 mm.

Affinities.—Two somewhat abraded seeds attached to the placenta as in life. The relative position of the seeds and the size of their ventral angles suggest that they were developed in a four-seeded berry. The seeds of *Vitis Thunbergii* Sieb. & Zucc., *V. pentagona* Diels & Gilg., *V. reticulata* M. Laws., *V. lanata* Roxb., and *V. labrusca* Linn. approximate to those of the fossil in size and form. But in all there are slight differences, and in all the chalaza is larger and more conspicuous. Almost all living species have a groove from the chalaza to the apex on the dorsal side, in which the raphe runs, and many species show, in addition, a groove between the chalaza and the base. *V. lanata,* although it is smaller than the fossil, most nearly resembles it. All the comparable living species belong to the section Euvitis of the genus *Vitis,* and to one of the two sub-sections Labruscae and Labruscoideae (Planch.), the members of which inhabit the warm and temperate regions of North America and Eastern Asia.

V. 22790 Holotype, figured Pl. XIX, figs. 1, 2. Two seeds still attached to a pyritized placenta as in life. *Reid & Chandler Coll.,* Minster, 1928.

Vitis minuta n. sp.

Plate XIX, figs. 3, 4.

Diagnosis.—Seed-cast obovoid, ventrally angled along the raphe ridge at an angle of 90°; chalaza about one-third of the length from the apex, sub-circular, with a narrow groove to the base; ventral infolds long, straight, narrow; apical sulcus for raphe wanting; length from hilum, 3·5 mm.; breadth, 2·5 mm.; thickness, 2·25 mm.; thickness of testa, 0·25 mm.

Holotype.—V. 22791.

Description.—*Seed:* Small, obovoid. Ventral face faceted, with a median longitudinal angle of 90°; raphe-ridge extending about three-fifths the length of the ventral face, fairly broad, and almost parallel-sided; longitudinal infolds on each side of the raphe-ridge long, nearly straight, narrow (Pl. XIX, fig. 4). Dorsal face rounded, chalaza fairly large and almost circular, situated at about one-third the length of the seed from the apex. Raphe ridge broad especially at the apex of the seed, which was probably not grooved. A narrow groove runs from the chalaza to the base (Pl. XIX, fig. 3). Testa fairly thick, formed of two coats; the inner coat of close hard cells, arranged in a columnar manner, giving rise to a pitted or granulated surface; the outer coat thin, formed of thin-walled polygonal cells; externally very small elongate cells give rise to fine striations which diverge from the chalaza. Tegmen with a finely granular surface of small polygonal cells. Length of seed, 3·5 mm.; length of internal cast, 2·8 mm.; breadth of seed, 2·75 mm.; breadth of internal cast, 2·25 mm.; thickness of testa, about 0·25 mm.

Remarks.—The specimen was preserved in a block of sandy limestone from Assington, Suffolk. Originally only the dorsal surface of the seed was exposed, showing the internal cast with the chalaza, to which a portion of the raphe still adhered. The evidence, although suggestive of *Vitis*, was not conclusive, so we removed the internal cast from the matrix and thereby revealed the ventral side with characteristic longitudinal ruminations. The decayed remains of the testa cling in patches between the internal cast and the hollow external cast of the seed. The thin outer layer of polygonal cells is preserved here and there, and its outer striate surface is impressed upon the surface of the matrix. A layer of infiltrated calcite lies between the testa and tegmen and forms almost the whole surface of the internal cast. It is chipped away in one part, revealing the tegmen. The cells are not sufficiently clearly defined for measurement.

AFFINITIES.—The relationship of this specimen to Vitaceae is indisputable; it is similar in size, shape, structure, thickness of the testa, and other characters to *Vitis Thunbergii*, in which the longitudinal infolds are somewhat shorter and the chalaza slightly larger. The only clear distinction we have been able to find between the fossil and *V. Thunbergii* is the cell-structure of the external surface. In the former the cells are finer, narrower, and more elongate, and are more like, but yet finer than, those of *V. lanata*. We have seen no living species with such fine striations. *V. Davidii* var. *cyanocarpa* Gagnep. from Western China is about the same size as the fossil, but differs in having ventral infolds, which are slightly concave towards the raphe ridge. The relationship is certainly with the section Euvitis (Planch.) of the genus *Vitis*. The specimen is much smaller than *V. semenlabruscoides*, which is the next smallest grape-seed hitherto found in the London Clay of Sheppey. It cannot therefore be referred to that species.

V. 22791 Holotype, figured Pl. XIX, figs. 3, 4. A seed-cast (external and internal) preserved in a block of limestone from Assington, Suffolk. The internal cast has been isolated from the block containing the external cast to facilitate photography and study. *John Brown Coll.*, 1860.

Vitis bognorensis n. sp.

PLATE XIX, fig. 5.

DIAGNOSIS.—Seed obovoid; chalaza elongate-oval, gradually narrowing into the raphe; with a broad shallow groove below; length, 4 mm.; breadth, 3 mm.

HOLOTYPE.—V. 22792.

DESCRIPTION.—*Seed:* Obovoid, with elongate-oval, depressed chalaza which gradually narrows above into the raphe. A broad shallow groove runs from the chalaza to the base of the seed. Testa, as seen in section, formed of cells arranged in a columnar manner. Length of seed, 4 mm.; breadth, 3 mm.

REMARKS.—Two specimens from the soft rock of the London Clay, Bognor. Both show the dorsal side of the seed only. The specimen which best shows the form is the internal cast of the convex dorsal surface of a seed, with remains of carbonaceous matter clinging all over the long oval chalaza. This is consequently very clearly defined, the white matrix of the cast contrasting with the brown chalaza as clearly seen in the figure. The second specimen is the hollow mould of the exterior of the convex dorsal surface of a seed, the remains of the testa being preserved within the hollow, more especially over the chalaza, which has the same narrow elongate form as in the specimen first described. This second specimen clearly shows the testa over the chalaza to be thick and columnar in section. Both specimens are imperfect in outline, the internal cast being broken at the sides near the base, and the external mould having lost the apex.

Affinities.—The characters described above are those of the seeds of *Vitis*. There can be no doubt that both specimens belong to a single species which differs from any hitherto found in the London Clay in its remarkably long narrow chalaza. In the absence of information relating to the ventral surface with its lateral depressions, the species cannot be fully described. But even so, the form of the seed is so well-defined, and the chalaza so distinctive, that there would be no difficulty in determining other specimens belonging to this species, should they be discovered. In view of this fact, and of the further fact that determinable plant remains from the Bognor Rock are so rare, we have ventured to give the seeds a specific name, in spite of partial ignorance of their characters, and have called them *Vitis bognorensis*.

V. 22792 Holotype, figured Pl. XIX, fig. 5. An internal cast of a seed, with remains of the testa over the chalaza.

V. 22793 An external cast of a seed in a piece of soft rock. *Both are E. M. Venables Coll.*, London Clay (Soft Rock), Bognor.

Genus TETRASTIGMA Planchon

1887. In De Candolle, Monog. Phan., V, p. 423.

Tetrastigma globosa n. sp.

Plate XIX, figs. 6–8.

Diagnosis.—Seed-cast sub-globular, radially fluted on both faces, the flutings reaching to the chalaza; chalaza median, slightly sunk; apical sulcus narrow, raphe ridge narrow below, triangular above; ventral infolds long and narrow convex to the raphe ridge; length and breadth, 4·5 to 5 mm.; thickness, 2·7 mm.

Holotype.—V. 22794.

Description.—*Seed-cast:* Sub-globular, both dorsal and ventral faces being convex, scarcely narrowed at the base. Longitudinal infolds on the ventral face exceptionally long, being continued at the apex to the extreme margin, in their upper part markedly convex towards the raphe ridge, which is consequently broad, and triangular in outline above, although narrow below. The wide marginal part of the ventral face is conspicuously undulate or fluted, the wide undulations, about six on each margin, being radially directed (Pl. XIX, figs. 7, 8). The dorsal face is much inflated, ornamented like the ventral face with conspicuous radially directed undulations or flutings, six on each margin, and with a round slightly sunk median chalaza. Apex with a narrow groove along which the raphe passes from the ventral face to the chalaza on the dorsal face (Pl. XIX, fig. 6). Micropyle basal, marked by a slight elevation (cast of a canal) near the base of the dorsal face; hilum basal, at the termination of the raphe ridge. Testa thick, columnar, finely and beautifully pitted internally, the cells being about 0·016 to 0·025 mm. in diameter, external surface not seen; tegmen formed of small polygonal cells. Diameter of the holotype, 5 mm. ; thickness, 2·7 mm. ; diameter of a second specimen, 4·5 mm. ; thickness, 3 mm.

Remarks.—Three seeds represented by internal casts of the seed-cavity with remains of the testa adhering, especially in the deep longitudinal infolds on the ventral surface, which was protected from abrasion by a mass of pyrites in each of the deep infolds. Along the margins of these infolds the testa is seen in section and its columnar character is sometimes clearly visible. In one specimen a mud film, which penetrated between testa and tegmen, bears on its outer surface the impression of the internal cells of the testa. On the dorsal side of the seed this mud film has been partially chipped away and the internal cast of the tegmen is exposed, bearing on its surface the impression of the tegmen cells.

In describing the form of this species we have had to rely on that of the seed-cast. In living species of the family Vitaceae this corresponds very closely with that of the seed, on account of the uniform thickness of the testa. But, as will be seen when we come to study *Palaeovitis paradoxa*, in fossil seeds there may be exceptions to this rule, although these appear to be extremely rare.

Affinities.—A close study of the Vitaceae led us to conclude that the fossil most resembles *Tetrastigma*. Among unnamed species of vines in Kew Herbarium there was one with seeds which were almost identical in character. This specimen was labelled " No. 2541 Herb. F. R. Drummond, Simla, 1885. *Vitis* sp. in sylvis c. 5000 m. ultra Simla, Frutex subscandens." Mr. C. Fischer very kindly examined it for us and identified it as a species of *Tetrastigma* and " almost certainly *T. rumisperma* Laws." We think, therefore, that the fossil can be placed in the genus *Tetrastigma* without any hesitation.

Tetrastigma inhabits eastern Asia from China and the Himalayas through Cochin China, Tonkin, Ceylon, the East Indies, and New Guinea to Australia.

V. 22794 Holotype, figured Pl. XIX, figs. 6, 7. A seed, internal cast with slight remains of the testa. *Bowerbank Coll.*, Sheppey.

V. 22795 Figured Pl. XIX, fig. 8. An internal cast of an undistorted seed. *Reid & Chandler Coll.*, Minster, 1929.

V. 22796 An abraded seed-cast possibly belonging to *T. globosa*. *Reid & Chandler Coll.*, Minster, 1929.

Tetrastigma (?) longisulcata n. sp.

Plate XIX, figs. 9, 10.

Diagnosis.—Seed-cast roundly quadrilateral in outline, dorsi-ventrally compressed, apical groove shallow, dorsal face obscurely sulcate radially ; chalaza large, circular, central, with no groove to the base ; ventral infolds very long, convex to the raphe ridge ; raphe ridge narrow, triangular above ; length, 4 mm. ; breadth, 3·1 mm. ; thickness, 2 mm.

Holotype.—V. 22797.

Description.—*Seed-cast:* Roundly quadrilateral in outline, scarcely pointed at the base, dorsi-ventrally compressed. Ventral face with two conspicuous longitudinal infolds extending almost the whole length of the seed, sub-parallel below but diverging widely above, somewhat convex to the raphe ridge. This is very marked and long, reaching from the base almost to the apex. In the lower half it is narrow and nearly parallel-sided; in the upper half it gradually widens, so as to be triangular towards the apex (Pl. XIX, fig. 10). The raphe ridge passes into a broad but shallow groove at the apex of the seed, which extends on to the dorsal face and terminates in the large round chalaza at the middle of that face (Pl. XIX, fig. 9). There is no groove between the chalaza and the base. Dorsal face with obscure sulcae and ridges which diverge from the chalaza. Testa obscure, preserved only in one small patch, but the cast of its internal surface shows small polygonal cells about 0·025 mm. in diameter. The internal cast of the tegmen shows fine cells, apparently elongate, which radiate from the chalaza. These cells are about 0·01 mm. broad, but their length is uncertain. Length, 4 mm.; breadth, 3·1 mm.; thickness in plane of symmetry, 2 mm.

Affinities.—The specimen, which is merely an internal cast of the seed, is of marked form and character. *Tetrastigma formosana* Gagnep. is comparable in shape and in the form of its ventral infolds, but it is a larger species and its chalaza is smaller. A specimen in Kew Herbarium (No. 2345. B. Balansa, Pl. du Tonquin), which is placed among the unnamed sheets of *Tetrastigma*, has seeds closely similar in shape, and in the shape of the chalaza, of the ventral infolds and of the raphe ridge; but the seeds of this specimen are slightly smaller. We conclude that the fossil is allied to *Tetrastigma*.

V. 22797 Holotype, figured Pl. XIX, figs. 9, 10. An internal cast of a seed. *Reid & Chandler Coll.*, Minster, 1928.

Genus AMPELOPSIS Richard

1803. In Michaux, Fl. Bor. Am., I, p. 159.

Ampelopsis crenulata n. sp.

Plate XIX, figs. 11, 12.

Diagnosis.—Seed-cast obovoid, slightly channelled at the apex, dorsal face radially crenulate; chalaza long, tapering into the raphe, surrounded by a channel which is continued to the base; ventral infolds broad, slightly concave to the raphe ridge, occupying five-eighths of the length of the seed, raphe ridge narrow below, very broad and ill-defined above; length, 4 mm.; breadth, from 3·2 to 3·4 mm.; thickness, 2·5 mm.

Holotype.—V. 22798.

Description.—*Seed-cast:* Obovoid, slightly channelled at the apex. Ventral face convex, raphe ridge narrow at the base but gradually broadening upwards for about three-quarters of the length of the seed, after which it is merged in the general surface, there being neither ridge nor channel at the apex on the ventral face. Ventral infolds rather long, about five-eighths the length of the seed and slightly concave towards the raphe ridge (Pl. XIX, fig. 12). Dorsal surface highly convex with a rather broad shallow channel having a central ridge which arises at the apex. The ridge passes into the boss of the chalaza, and the channel forms a groove surrounding this boss and continued on the internal cast almost to the base of the seed. Chalaza long and narrow. From the chalazal groove to the margin the surface of the cast is more or less crenulate or fluted (Pl. XIX, fig. 11). Testa much worn, but apparently originally rather thick, columnar in section. Length of first specimen, 4 mm.; breadth, 3·2 mm.; thickness, 2·5 mm. Length of second, 4 mm.; breadth, 3·4 mm.; thickness, 2·5 mm.

REMARKS.—Two specimens from Minster. Both are internal casts of seeds in the same state of preservation, with the remains of the testa, much abraded, still clinging in the ventral infolds. Hence the description given above is that of the cast of the seed. One specimen is more markedly crenulate than the other, and in this one margin has more crenulations, where it abuts on the chalaza, than the other.

AFFINITIES.—Small seeds with rounded crenulations of the type seen in these fossils are very rare among the Vitaceae. We have only found them in *Ampelopsis orientalis* Planch., but this species otherwise differs from the fossil since its seeds are smaller, more convex dorsally, shorter in proportion to their breadth, cuneate below, with more marked, fewer, and broader crenulations, and with a much shorter and rounder chalaza. Nevertheless, it seems probable that the seeds belong to the genus *Ampelopsis*. We have, therefore, given them the name *A. crenulata*. The genus occurs in tropical and warm regions in Asia and America.

V. 22798 Holotype, figured Pl. XIX, figs. 11, 12. An internal cast of a seed.
V. 22799 A second cast, with the chalaza scar broken.
Both are Reid & Chandler Coll., Minster, 1929.

Ampelopsis rotundata n. sp.

PLATE XIX, figs. 13–17.

DIAGNOSIS.—Seed sub-globose, contours rounded but with slight flutings around the chalaza; chalaza very large, oval, gradually narrowing into the broad raphe, with a slight groove to the base; ventral infolds markedly concave towards the raphe ridge, occupying about two-thirds of the length of the seed; raphe ridge fusiform in outline; length, 4 mm.; breadth, 3·75 mm.; thickness, 3·25 mm.

HOLOTYPE.—V. 22800.

DESCRIPTION.—*Seed:* Sub-globular, but bluntly pointed at the base, with nearly smooth contours. Ventral face slightly convex without either ridge or groove at the apex; the raphe ridge transversely rounded, rather broad below then rapidly broadening and again narrowing so as to be fusiform in outline, extending to within a quarter of the length of the seed from the apex, where it merges with the rest of the surface. Longitudinal infolds on the ventral face rather narrow, markedly concave towards the raphe ridge, occupying about two-thirds the length of the seed (Pl. XIX, figs. 15, 16). Dorsal face very highly convex, with a shallow broad groove at the apex which passes into the depressed chalazal area. The groove is almost entirely occupied by a median ridge, the raphe, which is continued into and gradually expands to form a long oval convex chalaza. In a perfect specimen the groove continues to the base, below the chalaza. Around the edge of the chalaza there are slight flutings on the surface of the seed (Pl. XIX, figs. 13, 14). Testa (much worn) thin and columnar in section. Length of seed, 4 mm.; breadth, 3·75 mm.; thickness, 3·25 mm.

Affinities.—Two seeds from Minster. One specimen has the testa almost perfect (Pl. XIX, figs. 13–15), the other is the internal cast of a seed to which a considerable portion of the testa still adheres although it is much worn (Pl. XIX, figs. 16, 17).

The seeds are remarkable for their very globose form, but one specimen is faceted along the median line on the ventral face, indicating the presence of more than one seed in the berry in this particular instance. Various vines belonging to the genus *Ampelopsis* have globose seeds, but none exactly corresponds with the fossil. The living species, *A. heterophylla* Sieb. & Zucc., which, with its varieties, most nearly resembles it, may have globose seeds of about the same size, but their ventral infolds are straight and divergent so as to make the raphe ridge triangular, not fusiform. While we cannot, therefore, relate it very definitely with any living species, we think the affinity is undoubtedly with the genus *Ampelopsis*, and we have given it the name *A. rotundata*. *A. heterophylla* is an inhabitant of China and Japan.

V. 22800 Holotype, figured Pl. XIX, figs. 13–15. A seed with testa preserved.
V. 22801 Figured Pl. XIX, figs. 16, 17. An internal cast of a seed.
Both are Reid & Chandler Coll., Minster, 1929.

Genus CAYRATIA Jussieu

1823. Ex Guill. Dict. Class. Hist. Nat., IV, p. 346.

Cayratia (?) *monasteriensis* n. sp.

Plate XIX, figs. 18, 19.

Diagnosis.—Seed-cast sharply faceted on the ventral face, otherwise with smooth contours, slightly channelled at the apex; chalaza circular, shallow, nearly central, with a slight channel below. Ventral infolds long, parallel to one another and to the raphe below, but diverging above so as to be convex to the raphe ridge; raphe ridge sharply angled and narrow below but triangular above. Length, 4·5 mm.; breadth, 3·5 mm.; thickness, 2·5 mm.

Holotype.—V. 22802.

Description.—*Seed-cast:* Slender, oval in outline, slightly emarginate at the apex and pointed at the base, with smooth contours. Ventral face faceted so as to form a conspicuous raphe ridge, the facets being nearly flat (probably indicating three or four seeds in the berry). The ridge gives place at the apex to a shallow broad channel. Lateral infolds on the ventral face exceptionally long, narrow, parallel to one another and to the raphe ridge below, but diverging above so as to be convex to the ridge (Pl. XIX, fig. 19). Dorsal face convex, slightly emarginate at the apex, and with a broad shallow groove leading to the shallow round chalaza which is situated about the middle of the face. From the chalaza a shallow median groove passes to the base. Around the margin of the chalaza the nut is very obscurely fluted, the flutings being narrow and rather numerous (Pl. XIX, fig. 18). Testa thin, columnar in section, inner surface tubercled, the tubercles being about 0·016 to 0·025 mm. in diameter. Length of seed, 4·5 mm.; breadth, 3·5 mm.; thickness, in plane of symmetry, 2·5 mm.

AFFINITIES.—Two seeds; internal casts to which a small portion of the testa clings in the ventral depressions and in the apical groove. Both casts show a pitted surface corresponding to the tubercled surface of the interior of the testa.

The seeds have all the characters of Vitaceae, but such long, narrow, ventral infolds, parallel near the base and diverging near the apex, are unusual in the family. The seeds of *Cayratia Thomsoni* Laws. are of the same size, of somewhat similar shape, and have similar ventral infolds, but the chalaza in that species is slightly longer and narrower than in the fossils. The seeds of the genus *Cayratia* are on the whole more angular than the fossil seeds, especially around the margin, while the thickness from back to front is very slight in most species of *Cayratia* as compared with the fossil. It is possible that these Sheppey seeds should be referred to an extinct genus, but since *Cayratia* shows the closest similarity among living forms, we have placed them tentatively in that genus. *Cayratia* is confined to eastern Asia.

V. 22802 Holotype, figured Pl. XIX, figs. 18, 19. An internal cast of a seed with remains of testa.
V. 22803 A slightly mutilated internal cast of a seed.
Both are Reid & Chandler Coll., Minster, 1929.

Genus PALAEOVITIS nov.

DIAGNOSIS.—Seed sub-globular, slightly compressed dorsi-ventrally, contours smooth, apex with a shallow depression; chalaza sub-circular, sub-central, with a shallow groove below; ventral infolds short, straight, slightly diverging; raphe ridge broad, not continued above the infolds; length, 7·5 mm.; breadth, 7·5 mm.; thickness, 5·5 mm.; thickness of testa, 0·75 to 1·5 mm. Seed-cast sub-circular in outline, with slightly crenulate margin, compressed dorsi-ventrally, with broad marginal crenulations separated by sharp ridges which alternate on the two faces, apical hollow, broad and shallow, base pointed; chalaza very large, occupying most of the dorsal face, shallow; ventral infolds and raphe ridge as described for the seed, except that the ridge is more sharply angled.

GENOTYPE.—*P. paradoxa* n. sp.

Palaeovitis paradoxa n. sp.

PLATE XIX, figs. 20–27.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22804.

DESCRIPTION.—*Seed:* Almost certainly solitary in the fruit, large, sub-globular but slightly compressed dorsi-ventrally, contours smooth and rounded. Ventral face with two short, broad, longitudinal infolds which are straight, or slightly concave towards the raphe ridge; raphe ridge broad and conspicuous, occupying the lower two-thirds of the seed, not continued into the upper part of the seed (Pl. XIX, fig. 21). Apex somewhat flattened and having a very shallow depression which leads to the sub-circular chalaza at the middle of the dorsal face (Pl. XIX, figs. 20, 22). The chalaza appears to have been slightly crenulate at the margin (Pl. XIX, fig. 22). A slight groove extends between it and the base on the dorsal face. Testa exceptionally thick, but of varying thickness, formed of cells arranged in a columnar manner (Pl. XIX, fig. 23), which give rise to polygonal pits of very variable size on the internal surface; the pits vary in diameter from about 0·025 to 0·05 mm. Tegmen formed of fine polygonal cells, about 0·015 mm. in diameter. Length of seed, 7·5 mm.; breadth, 7·5 mm.; thickness in plane of symmetry, 5·5 mm.; thickness of testa, 0·75 to 1·5 mm.

The cast of the seed-cavity differs greatly in form from the seed itself, owing to the varying thickness of the testa (Pl. XIX, figs. 23, 27). The seed has a smooth globose contour, whereas the cast is markedly crenulate on both faces, and its margin also is slightly crenulate. Like the seed it is circular in outline, except for the slight marginal crenulations, a broad shallow groove at the apex, and a rather conspicuous point at the base (Pl. XIX, figs. 24, 25). And, like the seed, it is convex ventrally, but the raphe ridge is sharper and the infolds broader and more conspicuous (Pl. XIX, fig. 24). The dorsal face on the contrary is very different. Its surface is marked by a large shallow central chalazal depression which occupies the greater part of the face (Pl. XIX, fig. 25), giving it a very different contour from that of the seed itself, where the chalaza appears as a round central boss with a slight groove separating it from the rest of the convex surface (Pl. XIX, fig. 22). The crenulations on both faces are formed by sharp radially directed ridges, about twelve on each face. On the ventral face they extend from the infolds to the margin, and on the dorsal face from the chalazal depression to the margin, on both faces becoming sharper and more marked as they reach the margin. The ridges alternate in position on the two faces, their marginal extremities being joined by a zig-zag ridge (Pl. XIX, fig. 26). Or alternatively it may be said that each ridge bifurcates at the margin, the bifurcations being common to the ridges of both faces.

Remarks.—Ten specimens. Two were virtually perfect with testa almost complete (Pl. XIX, figs. 20–22). A third showed the testa for the most part intact, but broken at the apex, thus exhibiting the form of the internal cast (Pl. XIX, fig. 27). The others are all internal casts with little or no remains of the testa. The third specimen mentioned gave the clue to the identity of the casts and the perfect seeds, but in order to satisfy ourselves definitely we fractured both the perfect specimens. These and the casts differ in form in a very remarkable manner, as will be gathered from the descriptions. On this account we have described both states of preservation; otherwise one might easily fall into the error of regarding perfect seeds and internal casts as two distinct species.

Affinities.—We have never met with any living species showing such marked difference between the form of the seed itself and of the seed-cavity as in this fossil, though we have had comparatively limited opportunities of examining the seed-cavity in living seeds. The large, fluted seeds of the genus *Tetrastigma* have not the smooth, rounded external contours of the fossil; these suggest alliance with *Vitis* or *Ampelopsis*, but no species in these genera approaches the fossil in size, and presumably it must represent some extinct genus. We have given it the name *Palaeovitis paradoxa*.

V. 22804 Holotype, figured Pl. XIX, figs. 20, 21. A seed with much of the testa remaining. *Reid & Chandler Coll.*, Warden Point, 1928.
V. 22805 Figured Pl. XIX, figs. 22, 23. A slightly distorted seed with well-preserved testa and tegmen, fractured to show the thickness and structure of the testa. *Reid & Chandler Coll.*, Minster, 1928.
V. 22806 Figured Pl. XIX, figs. 24–26. An internal cast of a seed. *Bowerbank Coll.*, Sheppey.
V. 22807 Figured Pl. XIX, fig. 27. A seed with the testa broken, exposing in part the internal cast. *Reid & Chandler Coll.*, Minster, 1929.
V. 22808 Six seeds (mostly casts). *Reid & Chandler Coll.*, Minster, 1929.

Family ELAEOCARPACEAE

Genus ECHINOCARPUS Blume

1825. Bijdr., p. 56.

Echinocarpus priscus n. sp.

Plate XIX, figs. 28–35.

Diagnosis.—Fruit sub-globular; pericarp thick, formed of twisted and gnarled strands of fibres. Length, 25 mm.; diameter, 25 mm. Seed, length, 7 mm.; diameter, 5·5 mm.

Holotype.—V. 22809.

Description.—*Fruit:* Sub-globular, syncarpous, five-loculed, each locule one or two-seeded. Exocarp thick, formed of tangled masses of fibres, the thick strands of which are twisted and contorted in a remarkable way. Towards the periphery these strands are directed radially; the interspaces between them are filled with parenchyma (Pl. XIX, figs. 30, 31). Endocarp formed of two or three layers of fibres, not contorted as are those of the exocarp, but aligned obliquely. In each layer the direction of the fibres varies slightly, but all are oblique. The locule-lining is also formed of a layer of oblique fibres (Pl. XIX, fig. 31). Along the dorsal angle of each locule is a groove which probably carried a bundle of fibres, but we have not actually seen this bundle. The fibro-vascular bundles associated with the placentas evidently entered at the apex of the locule, the pendulous seeds being attached at this end. Length of fruit, 25 mm.; diameter, 25 mm. Length of a large locule, 16 mm.; breadth, about 8 mm.; thickness, 7 mm.

Seed: Obovate, anatropous, micropyle and hilum at the narrow end, chalaza large, round and conspicuous at the broad end (Pl. XIX, fig. 35), raphe probably ventral. Testa rather more than 0·1 mm. thick. External surface formed of polygonal cells about 0·066 mm. in diameter. Next follows a series of cells arranged in a columnar manner, as seen in section, the diameter of the columns being about 0·016 mm. These, as they pass in towards the seed-cavity, merge into longitudinally arranged fibres. The worn surface of the seed usually shows this longitudinally striate layer in which disintegration has often emphasized the structure. The lining of the testa is formed of small polygonal cells 0·025 mm. in diameter (slightly inflated as seen on the internal cast). Length of seed, 7 mm.; diameter, 5·5 mm.; diameter of chalaza, 3 mm.

Remarks.—Four fruits, also one seed from Herne Bay which may probably belong to this species. In three of the fruits the greater part of the pericarp has either been abraded, or has broken away, leaving the casts of the locules exposed except at their extremities. The fourth fruit has most of the pericarp preserved. When these fruits were fractured, the seeds, with the decayed carbonized remains of the seed-coats, were exposed. The specimens were so impregnated with pyrites that it was impossible to trace the course of the various fibres satisfactorily. The worn fruits were sorted (by Ettingshausen ?) into a bottle containing several specimens of the fruits of Sapotaceae and of *Lobaticarpum* (Anacardiaceae ? p. 314). This is not a surprising mistake as the worn fruits, with their exposed locule-casts, closely resemble the worn sapotaceous fruits with their exposed seeds. It was only after fracturing the locule-casts and so exposing the seeds contained within, which were not those of Sapotaceae, that the distinction became clear.

Affinities.—The characters of fruit and seed point to an alliance with *Echinocarpus*. The fruits of this genus are stated, in the Genera Plantarum, to be three- to four-loculed, but in the carpological collection of Kew Herbarium there are two specimens of *E. dasycarpus* Bentham, collected by J. D. Hooker in Sikkim, each with five locules. The exterior of the fruit in this species is set with close, short, equal spines, making its surface like a door-mat; these spines very readily rub off and beneath them is a smooth surface. The fruit dehisces loculicidally, the walls are formed of radially directed rope-like fibres, which become matted in the interior, interspersed with masses of parenchyma. The innermost layers of the fruit-wall are formed of coarse fibres aligned obliquely, those of adjacent layers lying at right angles to one another, thus producing a criss-cross effect. The fruits vary from 20 to 35 mm. in diameter. The placentation is axile; usually there are about ten pendulous ovules in each locule, but only one becomes mature. The seeds are obovate, anatropous, with a large external scar over the chalaza; the raphe is lateral. The testa is formed of (1) an outer skin of polygonal cells, slightly concave externally, 0·05 mm. in diameter; (2) within is a thick coat 0·1 to 0·15 mm. in diameter; the outer layers of this coat are compacted so that their structure is difficult to distinguish; they may or may not have a columnar arrangement, and they merge gradually into the inner, more conspicuous, layers of the coat which are formed of longitudinal fibres. The lining of the seed-cavity is formed of a thin coat of fine polygonal cells 0·025 to 0·03 mm. in diameter. A conspicuous circular scar marks the chalaza on the interior of the testa. A typical well-developed seed measures 9·5 mm. in length and 6 mm. in breadth.

In all important respects, therefore, the fruit and seed of the fossil are in agreement with the fruit and seed of *E. dasycarpus*. We have therefore no hesitation in referring the fossil to the living genus *Echinocarpus*, which occurs in China (Hong-Kong, W. Hupeh at 4,000 feet), Formosa, Further India, India, the Malay Peninsula and Archipelago, and Australia. Some species are small, and others are large trees.

V. 22809 Holotype, figured Pl. XIX, figs. 28–30. A fruit from which the carpel walls have been largely abraded, exposing the locule-casts. By fracture of some of the locule-casts, some of the seeds have also been exposed.

V. 22810 Figured Pl. XIX, figs. 31, 32. A fruit, now somewhat worn, fractured longitudinally to show the form and locule-lining.

V. 22811 Figured Pl. XIX, figs. 33, 35. A much abraded fruit, now fractured so as to expose the two seeds in a locule. A detached seed is figured (fig. 35) to show the chalaza, and fig. 33 is a fragment of the fruit with seeds embedded in pyrites in the locule-casts.

V. 22812 Figured Pl. XIX, fig. 34. A fruit, shattered into many fragments. Some of the seeds can be clearly seen, and one is figured.

All the above are from the Bowerbank Coll., Sheppey.

V. 22813 A seed, probably belonging to this species. *D. J. Jenkins Coll.*, Herne Bay.

Echinocarpus sheppeyensis n. sp.

Plate XX, figs. 1–3.

Diagnosis.—Fruit ovoid; pericarp thinner than in *E. priscus*, the fibres composing it not forming thick gnarled strands. Length, 26 mm.; diameter, 16 mm. Seed, length, 10 mm.; diameter, 5 mm.

Holotype.—V. 22814.

Description.—*Fruit:* Ovoid, five-angled, five-loculed, dehiscing loculicidally along the angles. One locule only has a developed seed (Pl. XX, figs. 2, 3); the others are abortive. Carpel wall thick, formed of fibres embedded in parenchyma. Septa formed of many layers of sinuous fibres variously directed. When layers having different directions overlie one another they give a criss-cross effect. Length of fruit, 26 mm.; breadth (when perfect), about 16 mm.

Seed: Ovoid, rounded at one end, where there is a large, round chalazal scar, obtusely pointed at the hilar end. Testa formed externally of flat polygonal cells, 0·025 to 0·05 mm. in diameter, but smaller at the two extremities of the seed. Within is a series of columnar cells, each of which curves at right angles and runs longitudinally in the inner part of the coat; these inner ends are exposed as fine longitudinal fibres when the coat begins to decay. Over the chalaza irregularly polygonal cells radiate from its centre. Length of seed, 10 mm.; breadth, 5 mm.

Remarks and Affinities.—One specimen, which had fallen to pieces before it came into our hands. In one locule there is a large seed; the other locules are abortive. The similarity, almost amounting to identity, of this seed with those of *Echinocarpus priscus*, makes it certain that the two must be closely related, although the appearance of the two fruits is very different. *E. sheppeyensis* has completely dehisced so that the carpels have separated; whilst in *E. priscus* they have either remained united, or have been almost completely abraded. Another difference is seen in the carpel walls, which do not appear to have been so thick in *E. sheppeyensis* as in *E. priscus*, nor do the fibres composing them form gnarled and massive strands.

Apparently, too, the locules and fruits were narrower in *E. sheppeyensis*, although this may be a result of the undeveloped state of all but one locule. Such differences may in part be accidental, depending on conditions of fossilization and degree of abrasion, but more probably they are specific, particularly the differences in the thickness and fibrous structure of the pericarp.

V. 22814 Holotype, figured Pl. XX, figs. 1–3. A fruit which has dehisced loculicidally showing a seed in one locule. One segment is much shattered. *Bowerbank Coll.*, Sheppey.

Family TILIACEAE

Section *Tilieae* (Schumann)

Genus CANTITILIA nov.

Diagnosis.—Fruit ovoid, four- or five-loculed; many seeded, but only two or three seeds maturing; placentation axile; dehiscence loculicidal; pericarp of three coats of which the middle is thick but formed of delicate thin-walled parenchyma. Length, 6·5 to 13 mm.; breadth, 5 to 11·5 mm. Seed obovoid, anatropous, with a large round chalaza; testa formed of four coats: (1) a superficial layer of elongate cells; (2) parenchyma with secreting cells; (3) compact coat columnar in section; (4) parenchyma. Length, 4 to 5 mm.; breadth, 3 to 5·5 mm.

Genotype.—*C. polysperma* n. sp.

Cantitilia polysperma n. sp.

Plate XX, figs. 4–11.

1879. *Solenostrobus semiplotus* (Bowerbank): Ettingshausen, p. 392.
1879. *Wetherellia variabilis* Bowerbank: Ettingshausen (pars), p. 396.
1879. *? Carpolithes hydrophylloides* Ettingshausen, p. 396.

Diagnosis.—That of the genus.

Holotype.—V. 22815.

Description.—*Fruit:* Ovoid, five- (rarely four-) loculed, syncarpous, many-seeded. Placentation axile, the seeds being attached to a stout median axis, with the chalaza turned to the periphery of the fruit. There are about five seeds in each locule, arranged in two rows, but usually only one, two, or, perhaps, three come to maturity in the whole fruit. Dehiscence loculicidal. Carpel wall of three coats:

(1) A compact outer coat formed of parenchyma and radially arranged elongate cells, smooth or finely pitted on the outer surface, on which are five longitudinal grooves carrying strong bands of fibres which mark the planes of dehiscence; on its inner surface there is a network of branching and anastomosing fibres which arise from the longitudinal strands described above (Pl. XX, fig. 5).

(2) A thick mass of loose-textured, extremely thin-walled, coarse-celled tissue, of which the structure is obscured or obliterated by impregnation with pyrites. In the best preserved specimen this tissue appears to be spongy parenchyma (Pl. XX, fig. 9) traversed by fibres which are given off from the network outside.

(3) A thin smooth layer which lines the locules, and is formed of elongate cells which diverge from the axile placentas.

The fibrous axis gives off radial branches which appear ultimately to unite with the fibres of the outer coat in forming the network already described. Owing to the unequal development of the seeds and the extreme thinness of the septa, these latter may be pushed aside, torn, or sometimes completely obliterated. Again, the axis may be displaced. In all fruits, whether abortive or not, although more especially in abortive specimens, the locules are small in comparison with the size of the fruit (Pl. XX, fig. 8). Length of fruit, 6·5 to 13 mm.; breadth, 5 to 11·5 mm.

Seed: Obovoid when fully developed, differing greatly in size according to the degree of development, anatropous, with the hilum and micropyle at the narrow end, and the chalaza, which is large and round, at the broad end (Pl. XX, fig. 11); the lateral raphe is a flat band of fibres. The cells of the successive integuments radiate from the micropyle and chalaza at the opposite ends of the seed. (1) The external surface is irregularly ridged and rugose, formed of long fusiform or oblong cells (0·016 to 0·025 mm. broad) somewhat sinuously, but on the whole longitudinally, arranged. (2) Within this surface layer is a coat of parenchyma containing numerous globular secreting cells, often about 0·05 mm. in diameter. This coat is especially well-developed and thick around the chalaza, where it may reach 0·5 mm. in thickness; towards the base of the seed it becomes thinner, and the secreting cells are largely replaced by parenchyma. When the coat above described is separated from the next within, as a result of fossilization, so that a film of pyrites has penetrated, the surface impression of the parenchyma on this film has a shagreen-like appearance, due to the equiaxial polygonal cells of which the parenchyma is composed. (3) This parenchymatous coat is followed by a thin compact coat of fairly uniform thickness (about 0·025 mm.) with well-defined surfaces, columnar in section, but, as seen superficially, the cells of which it is composed are small, narrow, and oblong (about 0·008 to 0·01 mm. broad). This thin columnar coat is usually preserved as a carbonaceous layer among the other highly pyritized integuments. It is pierced by an aperture at the chalaza. (4) Within it is another parenchymatous coat, the cells of which vary in diameter from 0·025 to 0·05 mm. It is thick in the chalazal region, but relatively thin elsewhere. Like the first-mentioned coat of parenchyma (coat 2), it may be separated from the columnar coat as the result of fossilization by an interposed film of pyrites; the surface of the film has a shagreen-like appearance, due to the small equiaxial cells of which the coat is formed. (5) The innermost layer, or tegmen, is formed of quadrilateral or polygonal cells of irregular shape and size, varying in diameter from 0·05 to 0·1 mm. The large chalaza is very conspicuous on this coat (Pl. XX, fig. 11). Length of ripe seeds, 4 to 5 mm.; breadth, 3 to 5·5 mm.

REMARKS.—Over a hundred fruits and several isolated seeds from Sheppey. One fruit has also recently been found at Herne Bay. The external appearance of these fruits differs greatly according as the outer coat is or is not preserved (most are entirely without it). The surface may therefore be smooth and grooved, or conspicuously net-veined (Pl. XX, figs. 5, 7). Some of the fruits are crushed in one direction, others in another, which suggests that originally they were relatively soft.

In reviewing the evidence we were at first confronted with a great difficulty. Although in structure, both of carpels and seeds, all the fruits are alike, yet they show a remarkable difference in the number of the locules and in the size of the seed. Some are, apparently, one-loculed with a few seeds, others are five-loculed with many seeds. Are two species, or, perhaps, even two genera represented? Only the chance find of a fruit with large seeds in one of its locules and small seeds in another solved the difficulty. In the few-seeded, apparently one-loculed fruits, a few seeds only have developed, and by them the axis has been displaced and the septa either distorted or destroyed. In the five-loculed fruit the seeds are abortive, and the axis and septa have remained in position. This solution was later confirmed by closer study of the few-seeded specimens. Another difficulty of interpretation occurs in regard to the number of coats which form the testa. Some specimens appear to have a larger number of distinct coats, or layers, than others, but this is due to the separation or non-separation of some coats as the result of fossilization. In very many of the London Clay fruits and seeds such differential separation of coats and layers is accompanied by the infiltration of pyrites. In the present case the differences thus arising rendered it not only difficult to relate the fossils among themselves, but also to relate them to living forms.

The species was illustrated by Crow in his manuscript catalogue (1810, Nos. 553?, 643, 716?).

Affinities.—Five-loculed, loculicidal fruits with axile placentation and anatropous seeds of similar shape with large conspicuous chalazas at their broad ends occur in the Malvales. In this group, moreover, the genera with anatropous seeds often show a similar succession of coats in the testa (cf. also p. 399). There may be a compact, well-defined, columnar coat of uniform thickness which is pierced by a foramen at the chalaza, and is flanked on each side by a coat of parenchyma peculiarly well-developed and thickened around the chalaza, so that the seeds have a highly characteristic appearance in longitudinal section (cf. text-fig. 14, p. 398). This succession of coats is essentially that described in the fossil seeds. Hence the structure of both fruit and seed point to a relationship with the Malvales. And in no other group, so far as we have been able to discover, are all the characters of the fossil united. After a careful study of the group in Kew Herbarium we found that no living genera of either the Malvaceae or Sterculiaceae correspond very closely with the fossil species. But we did find that the elucidation of the specimens was greatly assisted by a comparison with *Tilia* Linn. of the family Tiliaceae.

In this genus the fruit, which may be comparable in size with the fossil, is five-loculed, with a stout woody pericarp lined by a network of fibres; and occasionally, as, for example, in specimens of *T. argentea* Desf. in Kew Herbarium, there is a conspicuous layer of thin-walled, coarse-celled parenchyma between the fibrous layer and the locules, so that the locules are small in comparison with the size of the fruit, as in the fossil species. Further, the septa are thin and papery, the axis is fibrous, and there are two seeds in each locule, though almost invariably one seed alone develops in each fruit, the rest remaining abortive. In a specimen of *T. amurensis* Rom. sent by Mr. P. A. Nikitin, two seeds were developed, and we have also seen two developed seeds in other species. Usually the fertile seed pushes aside or ruptures the thin septa and the median axis, and occupies the whole seed-cavity. In all the above respects a close similarity to the fossil may be noticed. There is, however, the difference that in the living *Tilia* there are only two seeds in each locule while in the fossil there are four or five at least. Turning to the seeds themselves, the external surface of the seed of *Tilia* is very similar to that of the fossil. The coats within are comparable in succession, structure, and thickness except that the columnar coat is thicker in *Tilia* than in the fossil.

Although the number of seeds debars us from referring the fossil to *Tilia*, there are strong arguments for placing it among the Malvales and in the family Tiliaceae. No other living genus shows such close similarity to the fossil as *Tilia*, and the numerous resemblances suggest a near relationship, even though generic identity be out of the question. We have therefore referred the specimens to the family Tiliaceae, section Tilieae (Schumann), and have named them *Cantitilia*, to indicate their connection with Kent and their nearest living relationship. The genus *Tilia* grows under temperate climatic conditions. But judging by the associated flora, the fossil genus *Cantitilia* may have required warmer conditions than its living ally.

At the present time *Tilia* occurs in Europe, North Asia, and North America. In Asia it extends south to Korea, western Hupeh, and even Yunnan, but in the last-named region is found at great altitudes (10,000 to 12,000 feet). In North America it is recorded from warmer localities; for example, the woods of Jackson Co., Florida, and the river banks of Texas, and at 300 feet in the wet canyons of the Sierra Madre in Mexico.

V. 22815 Holotype, figured Pl. XX, fig. 4. An incomplete fruit with ripe seeds, fractured longitudinally to show the seeds and the displaced axis.

V. 22816 Figured Pl. XX, fig. 5. A well-preserved fruit, showing the network of fibres exposed by the abrasion of the external part of the fruit-wall.

V. 22817 Figured Pl. XX, fig. 6. A crushed fruit, figured to show the base and the five carpels.

V. 22818 Figured Pl. XX, fig. 7. A somewhat elongate fruit, with part of the exocarp preserved.

V. 22819 Figured Pl. XX, fig. 8. A fruit with immature seeds, showing the locules and the axis undistorted.

V. 22820 Figured Pl. XX, fig. 9. A fruit with mature seeds. Fractured transversely to show the obliteration of the locules and of any symmetrical arrangement.

V. 22821 Figured Pl. XX, fig. 10. A fruit with immature seeds, fractured transversely to show the axile placentation. The section passes through two galls which have partially destroyed the locules and the symmetry of the fruit.

V. 22822 Figured Pl. XX, fig. 11. A seed with a portion of the fruit-wall still adhering. The chalaza is very clearly seen.

V. 22823 Nine fruits of typical forms and sizes. One is fractured and shows the abortive seeds in the locule and the median axis.

V. 22824 A fruit fractured longitudinally, showing the axile placentation very clearly; the seeds are all abortive.

V. 22825 An isolated seed, the outer coat preserved around the chalaza. The micropyle is clearly visible on one of the inner coats.

V. 22826–29 Four fruits with mature seeds, variously fractured to show the arrangement of the seed-coats.

V. 22830 A detached mature seed, with the outer coat destroyed, fractured longitudinally.
V. 22831 A fruit, fractured to show the loculicidal splitting. The seeds are all immature.
V. 22832 Sixty fruits, and numerous additional fragments.
All the above specimens were in a jar labelled by Ettingshausen "*Wetherellia variabilis* Bowerbank."
V. 22833 A fruit, labelled by Ettingshausen "*Carpolithes* sp. nov. 2."
V. 22834 A fruit, apex detached, labelled by Ettingshausen "*Cupressinites semiplotus* Bowerbank." This corresponds with *Solenostrobus semiplotus* of Ettingshausen's published lists.
V. 22835 A fruit, now in fragments, the abortive seeds and characteristic fibrous network still visible.
All the above are from the Bowerbank Coll., Sheppey.
V. 22836 Thirty fruits. *Reid & Chandler Coll.*, Minster, 1928, 1929.
V. 22837 A fruit. *D. J. Jenkins Coll.*, Herne Bay.

Family STERCULIACEAE

Genus SPHINXIA nov.

DIAGNOSIS.—Fruit ovoid, five-loculed, with six or eight seeds in each locule arranged in two rows, syncarpous, dehiscence loculicidal; placentation probably axile. Length of largest specimen (locule-cast), 13 mm.; breadth, 12 mm. Seed sub-obovoid, probably anatropous, large circular chalaza turned towards the periphery of the fruit, micropyle towards the axis. External surface with irregular tags arising from the outer coat of the testa. Testa formed of three coats, the middle one compact and columnar in section. Length, 4·25 mm.; breadth, 2·75 mm.

GENOTYPE.—*S. ovalis* n. sp.

Sphinxia ovalis n. sp.

PLATE XX, figs. 12–23, text-fig. 14.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22838.

DESCRIPTION.—*Fruit:* Ovoid, five-loculed, with six or eight seeds in each locule arranged in two rows, syncarpous, dehiscing loculicidally; placentation almost certainly axile. Pericarp (as preserved) formed of irregular parenchyma (cells about 0·05 mm. in diameter) with a close network of branching and anastomosing fibres embedded on the outer surface; septa thin, formed of closely packed elongate cells which lie parallel to their surfaces; locule-lining formed of several layers of variously aligned elongate cells which have the appearance of contorted fibres, the cells of the innermost layer being transverse; the breadth of these cells is about 0·025 mm.; here and there polygonal cells (about 0·05 mm. in diameter) are associated with the elongate cells; the surface of the locules is irregularly undulate and rugose. The locules are continued to the fibrous axis, at the centre of which is a canal. Specimen 1: Length of fruit, 13 mm.; breadth, 9 mm. Specimen 2: Length of locule, 13 mm.; radius, 6 mm.; breadth of dorsal surfaces, 4 to 6 mm.

Seed: Sub-obovoid (possibly faceted by mutual pressure) with the narrow end, at which is the small micropyle, turned to the axis, and the broad end, at which is the large chalaza, turned outwards (Pl. XX, fig. 18); either anatropous or orthotropous, as indicated by the direction of the cells of the testa, and almost certainly anatropous, because the fibrous axis very strongly suggests axile placentation with the hilum adjacent to the axis, and the chalaza at the opposite end of the seed. Outer surface rugose or perhaps hairy. Testa formed of several coats (text-fig. 14):

(1) An outer coat formed of radially aligned rectangular cells, about 0·025 mm. in diameter. The number of these cells in the thickness of the coat, and their length, is very variable. Consequently the surface of the coat is raised into excrescences which may be as much as 0·6 mm. long (Pl. XX, figs. 16, 21, 23). They are particularly long and conspicuous over the chalaza and around the micropyle, where they frequently end in short tags or hairs each formed of a single cell. The impressions of large polygonal cells (0·03 to 0·05 mm. in diameter) in a few places exterior to the rough coat, makes it probable that originally the outer surface of the seed

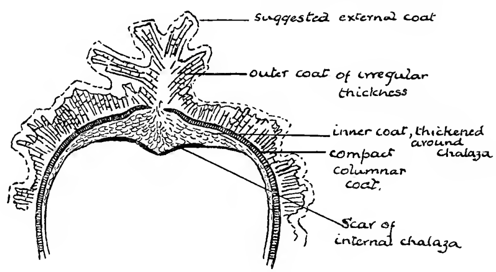


Fig. 14.—*Sphinxia ovalis.*—Diagrammatic longitudinal section through the chalazal end of a seed, showing the peculiar development of the coats.

may have been covered by a smooth layer of cells, now decayed (cf. *Trochetia* D.C.). The inner surface is formed of narrow elongate cells, about 0·025 mm. broad, which produce a fine longitudinally striate effect.

(2) Within the first coat is a second, close-textured and compact, about 0·05 mm. thick, with sharply defined inner and outer surfaces. It is formed of prismatic cells, about 0·025 mm. in diameter, having a columnar arrangement as seen in sections of the seed. The inner surface of this coat, which consists of a thin layer of fine elongate cells similar to those which line the outer coat, is longitudinally striate. At the centre of the chalaza the coat is pierced by an aperture.

(3) The next coat is formed of several layers of rectangular cells which converge towards the chalaza and micropyle, where it may be as much as 0·3 mm. thick, whilst elsewhere it is about 0·05 mm. thick. It passes, externally, into the chalazal aperture in coat (2), and internally forms a small protuberance beneath it (text-fig. 14). On its inner surface the well-defined circular scar of the inner chalaza (about 0·6 mm. in diameter) is conspicuous (Pl. XX, fig. 18).

The tegmen is smooth and shining, formed of elongate cells of variable length (0·02 to 0·025 mm. broad and about 0·03 to 0·035 mm. long), aligned longitudinally. The cells converge and become narrower towards the micropyle and chalaza. Length of seed (exclusive of outer coat with irregular prolongations), 2·4 mm.; breadth, 2·05 mm. Length with prolongations, 4·25 mm.; breadth, 2·75 mm.

Remarks.—Three fruits, and two carpels belonging to a fourth. The two carpels, and one of the fruits which had the pericarp preserved, were collected at Herne Bay; although this fruit had not dehisced, it was abraded and a seed was exposed. In one of the two other fruits, the exocarp is partly preserved but the fruit is broken and the internal structure is shown (Pl. XX, figs. 12–18); in the other the septa and fruit-walls have decayed so that the locule-casts are free. Each locule-cast has a median dorsal longitudinal ridge due to the infiltration of pyrites along the incipient fissures associated with loculicidal dehiscence (Pl. XX, figs. 19–23). The true surface of the seed is not exposed; but its impression is seen in small patches (p. 398), because the pyrites which fills the locules is so firmly entangled in the surface excrescences that these cannot be cleared from it. But the coat is constantly seen in section, and then the protuberances and hairs are clearly visible. The seeds tend to break along the dividing surface between coats (1) and (2) because these surfaces have separated so that a film of pyrites is intercalated. On its glistening outer surface, this film shows the impressions of the fine elongate cells which line the outer coat (1). A similar plane of weakness associated with a film of pyrites is found between coats (2) and (3). Except perhaps the cells of the outer coat (1), of the superficial arrangement of which nothing is known, the cells of all the coats are longitudinally aligned, and become smaller and convergent towards the micropyle and chalaza. Such alignment must imply that the seeds are either anatropous or orthotropous, and, as we have already seen, the relation of the chalaza to the axis of the fruit indicates that, almost certainly, they were anatropous.

Affinities.—The chief diagnostic characters of this fruit are found in its seeds, namely, in the form of the seeds, the coats which form the testa, and the character and position of the chalaza. Obovoid seeds; a rugose or hairy external surface to the testa, formed of an outer coat of variable thickness; a compact columnar coat pierced and sometimes incurved at the chalaza; a third coat with its chalazal thickening; and a large chalaza, as in the fossil, are distinctive of certain genera of the Malvaceae (section Hibisceae Schumann), the Sterculiaceae, and the Tiliaceae, all belonging to the order Malvales. In these families also occur ovoid, five-loculed, loculicidal fruits with axile placentation, numerous seeds in each locule, a network of fibres over the outer surface of the endocarp, and the locule transversely or obliquely striate. The Malvaceae are not clearly related, for all except four genera have curved seeds, and even these have a tendency to be curved, with the chalaza on the ventral face, not terminal as in the fossil.

In the Tiliaceae we have been unable to find closely comparable fruits, although certain genera have seeds with comparable characters.

In the Sterculiaceae many genera can at once be discarded either because they have fewer locules or seeds, or because of the marked asymmetry of the seeds, or because of their thin and papery capsules. But in certain genera (*Dombeya* Cav., *Trochetia* D.C., and in a lesser degree *Buettneria* Linn.) the capsules are stouter and comparable with those of the fossil, whilst the seeds may be rugose. In *Trochetia* the seeds have similar excrescences which show a similar structure to that seen in the fossil. In the seeds of Sterculiaceae the raphe lies just within the surface of the outer coat. Hence when, as in the fossils, the outer surface is not exposed, it would be invisible. Thus our prolonged study in Kew Herbarium shows that the fossils certainly belong to the Malvales, and that their closest affinity is with *Dombeya* and *Trochetia* of the family Sterculiaceae, although no living genus combines all their characters. Hence they probably belong to the section Dombeyeae of this family.

The living genus *Dombeya* grows in east tropical Africa, South Africa, Madagascar, and the Mascarene Islands. *Trochetia* grows only in Madagascar, the Mascarene Islands, and St. Helena. Other genera of the Dombeyeae are restricted to the Mascarene Islands, two only having a wider range to the East Indies, or Australia.

V. 22838 Holotype, figured Pl. XX, figs. 12–18. A fruit, with endocarp preserved, now fractured. It shows the several-seeded locules, the general form and character of the seeds, each with its large chalaza, the external rough coat of the testa embedded in pyrites, and the axial fibres. *Bowerbank Coll.*, Sheppey.

V. 22839 Figured Pl. XX, figs. 19–23. A fruit which has dehisced, liberating the locule-casts by the decay of the thin septa. The biseriate seeds are exposed by abrasion in the dorsal side of the locule-casts. The seed-coats are well seen, the ragged external coat forming an irregular outline with radial projections into the pyrites of the locule-cast. Within it are the casts of the successive seed-coats and of the seed-cavity. *Bowerbank Coll.*, Sheppey.

V. 22840 A fruit. *D. J. Jenkins Coll.*, Herne Bay.

V. 22841 Two carpels. *D. J. Jenkins Coll.*, Herne Bay.

Family DILLENIACEAE

Genus TETRACERA Linnaeus

1737. Gen., ed. I, p. 345.

Tetracera eocenica n. sp.

Plate XX, figs. 24–29.

Diagnosis.—Seed sub-globular, somewhat compressed dorsi-ventrally; hilar depression oval, deep; surface tessellated; dorsi-ventral diameter in plane of symmetry, 4·6 mm.; greatest diameter in same plane, 5·7 mm.; greatest diameter perpendicular to same plane, 5·4 mm. Seed-cast: radicular beak conspicuous; hilar depression broad transversely, deep; corresponding measurements to those for seed, 3·7 mm.; 4·3 mm.; 3·8 mm.

Holotype.—V. 22842.

Description.—*Seed:* Sub-globular, bisymmetric about a plane passing through the hilum, micropyle and chalaza, without lateral compression, but somewhat compressed dorsi-ventrally; campylotropous, the hilum sunk in a rather deep oval depression beneath the micropyle, from which a median ridge passes on to the dorsal surface, where it dies out (Pl. XX, fig. 26). On the internal cast of the seed the radicular end forms a conspicuous snout or beak (Pl. XX, figs. 24, 25, 28) overhanging the deep, broad depression of the hilum; the internal chalaza is a conspicuous, circular, or oval scar on the convex ventral surface of the seed adjacent to the hilar depression (Pl. XX, fig. 24). The testa is formed of several coats: (*a*) An outer coat, always much abraded, of polygonal, closely-set cells about 0·025 mm. in diameter, the ends of which form a tessellated surface. (*b*) A thin layer of thin-walled, irregular, loose-textured, polygonal cells (Pl. XX, fig. 29) which may be 0·1 mm. long and 0·03 mm. broad. Beneath the snout these cells tend to be transversely elongate and much smaller. (*c*) A compact, thin coat of small obscure cells. (*d*) A layer of small, irregular, quadrangular, or polygonal cells 0·025 mm. in diameter. (*e*) A thin layer (the tegmen ?) of thin-walled cells radially directed from the chalaza, elongate, with bevelled ends, and about 0·015 mm. broad. The successive coats above described are frequently separated from one another by films of pyrites. The apparent number of coats may have been exaggerated, as differential decay during fossilization may have separated coats formerly fused, thereby allowing the infiltration of pyrites between the separated layers. Over the chalaza, beneath the radicular snout, the testa is greatly thickened by a mass of fine parenchyma which lies between the two outer coats. Hence on the external surface of the seed the snout is almost completely masked. Dorsi-ventral diameter in plane of symmetry, 4·6 mm.; greatest diameter in same plane, 5·7 mm.; diameter perpendicular to plane of symmetry, 5·4 mm. Seed-cast: Dorsi-ventral diameter, 3 to 3·7 mm.; maximum diameter in plane of symmetry, 4 to 4·5 mm.; lateral diameter at right angles to this plane, 3 to 3·8 mm.

Remarks.—Sixteen specimens. Almost all are internal casts of the seed, but a few have traces, or considerable remains, of the testa. All are worn and polished so that in some cases almost every trace of cell-structure has disappeared. Several specimens show the chalaza clearly; in one or two the coarse-celled coat of the testa is rendered conspicuous by the contrast between the black, glittering cell-contents and the cell-walls outlined in white pyrites.

Affinities.—The characters of especial value in diagnosis are the campylotropous seed with its small snout-like radicular end, the form and position of the chalaza, and the character and succession of the coats of the testa. In order to trace the relationship, we examined as far as we could all families with campylotropous seeds. Most of these, such as Caryophyllaceae and Polygonaceae, are excluded by the marked lateral compression of their seeds, their sculpture, and the absence of a definite circular or oval chalazal scar. This absence in particular precludes relationship with *Basella*, the seeds of which are similar in form. In *Basella* the chalaza is a broad band of large transversely aligned cells or fibres lying across the re-entrant angle beneath the radicular prominence. The seed of *Celtis* (family Ulmaceae), with similar form and chalaza, is excluded from alliance by its cell-structure and by the conspicuous branching fibres on the chalazal scar. The only other family which combines a similarly shaped campylotropous seed, a circular chalaza similarly placed, and a tessellated testa formed of close-set polygonal cells is the Dilleniaceae. A study of the genera belonging to this family in Kew Herbarium showed that the seeds of the genus *Tetracera* most resemble the fossil. Some genera have seeds which are not comparable in size, and in all the other genera the seeds are more laterally compressed than those of the fossil. The only species of *Tetracera* we were able to examine closely was *T. potatoria* Afz. This seed, when covered by its testa, measures $4 \times 3 \times 3$ mm. The succession of coats is identical with that in the fossil. The external coat is black and shining, the large hexagonal cells forming a tessellated surface. Within this, and separate from it, is a layer of loose tissue formed of large, irregular, elongate, polygonal cells. The only apparent distinction is that the seeds of *T. potatoria* have a less-marked radicular snout than the fossil. But the difference is not really so marked as at first sight appears, and is dependent largely on the state of preservation of the fossil species. In the living species the testa is greatly thickened over the chalaza and beneath the snout, but is not thickened over the radicle; consequently, when deprived of the testa, as is the case with the bulk of the fossils, the beak-like shape is greatly emphasized. In those fossils in which the testa is preserved, the beak-like radicular prominence is obscured. The evidence therefore places the fossil in the genus *Tetracera*, and we have given it the name *T. eocenica*.

Tetracera is a genus inhabiting all the tropical regions of the world. Most species are climbers, but a few are trees.

V. 22842 Holotype, figured Pl. XX, figs. 24, 25. An internal cast of a seed, showing clearly the snout-like radicular prominence and circular chalazal scar.
V. 22843 Figured Pl. XX, figs. 26–28. A seed, with the hilum and remains of the testa, fractured longitudinally to show the radicular snout-like prominence on the internal cast of the seed-cavity.
V. 22844 Figured Pl. XX, fig. 29. An internal cast of a seed with remains of the testa, particularly the coarse, net-like cells of one of its layers.
V. 22845 A well-preserved seed with remains of testa, which has been chipped away on one side to show the cast of the seed-cavity. The chalaza, the radicular snout, and the succession of coats in the testa are clearly shown.
V. 22846 A seed-cast much worn and polished by abrasion.
V. 22847 A seed-cast, micropyle broken, showing chalaza.
V. 22848 Seven seeds or seed-casts.
All the above are Reid & Chandler Coll., Minster.
V. 22849 Three seed-casts. *Bowerbank Coll.*, Sheppey.

Tetracera (?) *cantiensis* n. sp.

Plate XX, figs. 30–33.

Diagnosis.—Seed ovoid, somewhat compressed laterally and dorsi-ventrally; hilar depression transversely curvilinear; surface rough (? tubercled). Corresponding measurements to those given for *T. eocenica*, 4 mm.; 5 mm.; 4 mm.

Holotype.—V. 22850.

Description.—*Seed:* Ovoid, slightly compressed laterally and dorsi-ventrally, and rather conspicuously and sharply ridged at the micropylar end; campylotropous, with the transverse, curvilinear hilar depression adjacent to the inconspicuous beak-like prominence of the radicle; chalaza large and round, median, close to the hilum. Testa formed of three coats, the outlines of the cells which form it being obscure. The outer coat is close and hard, formed apparently of fine, close parenchyma, the outer surface being rough and probably tubercled. The middle coat is formed of large cells, the impressions of which show in a few patches. The inner coat is finely striate, the striations radiating from the large chalaza. Dorsi-ventral diameter, 4 mm.; greatest diameter in plane of symmetry, 5 mm.; greatest diameter perpendicular to this plane, 4 mm. Seed-cast not completely seen.

REMARKS.—One almost perfect specimen, which we have made the type (Pl. XX, figs. 30, 31), and three smaller specimens, varying from 4 to 4·5 mm. in diameter, which probably belong to the species, but they are distorted and, since their outer coats are either completely or in part worn away, they appear relatively small. One of these doubtful specimens is also shrunken so that it appears faceted. All were found by ourselves at Minster in 1929. The perfect specimen was slightly obscured near the hilum and chalaza by adhering pyrites. In removing this, a small piece of the outer layers of the testa came away exposing the chalaza, and showing that the specimen was a little crumpled beneath the pyrites.

AFFINITIES.—There can be no hesitation in referring all these specimens to Dilleniaceae, and we think that probably they belong to the same species, on account of the similarity in shape (note particularly the sharp, narrow ridge at the micropyle, and slightly compressed form); but we base the species on the one perfect specimen. The shape and size correspond best with *Tetracera*, but we are uncertain whether the possibly tubercled surface forbids its inclusion in the genus; otherwise the coats of the testa in the fossil and in *Tetracera* agree. We have given it the name *Tetracera (?) cantiensis*.

The present species differs in shape from the two other fossil species of Dilleniaceae which are found in Sheppey: from *T. eocenica* in its rather larger size, regular ovoid form, lateral compression, curvilinear hilar depression and inconspicuous "beak"; from *T. (?) sheppeyensis* in its smaller size, ovoid form, more marked micropylar ridge, less conspicuous "beak," and in its curvilinear hilar depression.

V. 22850 Holotype, figured Pl. XX, figs. 30, 31. A seed with remains of testa.
V. 22851 Figured Pl. XX, fig. 32. A somewhat distorted seed, fractured to show the seed-cast and large chalaza. It may belong to this species.
V. 22852 Figured Pl. XX, fig. 33. A somewhat distorted specimen, which may belong to this species.
V. 22853 A distorted seed, broken into three fragments. May be referable to this species.
All are Reid & Chandler Coll., Minster, 1929.

Tetracera (?) sheppeyensis n. sp.

PLATE XXI, figs. 1–4.

DIAGNOSIS.—Seed globular; hilar depression almost wanting; radicular beak prominent. Diameter, 5·3 mm.

HOLOTYPE.—V. 22854.

Description.—*Seed:* Globular, with a small, rather sharp, ridged, beak-like prominence associated with the micropyle, hilar depression scarcely defined from the general surface; campylotropous, with a large, round chalaza close to, and beneath, the micropyle. Testa formed of several coats, the cells of which have not been very clearly distinguished. The outermost coat shows the confused impressions of large, close-set polygonal cells, in association with those of very small cells, but which is the external of these two layers it is impossible to tell.

Within this coat lies one formed of many layers of cells. It is much carbonized and the cells have decayed and cannot now be distinguished, but in one patch, where it is more pyritized and seen in section, there appear to be rather large spaces filled with structureless pyrites, as though they represented the infilling of large cells. The lower portion of this coat shows a finely striate surface formed of small cells. Within, and separated from this coat by a thick layer of structureless pyrites, is the tegmen, with which is associated the large round scar of the internal chalaza (Pl. XXI, figs. 3, 4). The uniformly minute cells of the tegmen are aligned so as to radiate from the margin of the chalaza, giving rise to fine radiating striae in this part. Diameter of seed, 5·3 mm.

Remarks.—One specimen, which, except for the impression of surface cells, and the small ridge passing into the beak of the micropyle, showed no other characters. On fracturing the seed, most of the testa chipped away and shattered, exposing the chalaza and the various coats described above.

Affinities.—The shape, and the character of the coats, the chalaza, and the micropyle all indicate that the species belongs to the family Dilleniaceae, and is probably a species of *Tetracera;* but we have only referred it doubtfully to the genus because we have not seen the separate coats sufficiently clearly to compare them all. It differs from *T. eocenica* in being much larger and more globular, and in having a less conspicuous micropylar beak, because the hilar depression beneath it is less marked. *T.* (?) *cantiensis* is distinguished from it by characters discussed on p. 403. We have named it *T.* (?) *sheppeyensis.*

V. 22854 Holotype, figured Pl. XXI, figs. 1–4. A seed with remains of testa. The chalaza is clearly shown. *Bowerbank Coll.*, Sheppey.

Family TERNSTROEMIACEAE

Genus ?

Plate XXI, figs. 5–8.

Description.—*Fruit:* Ovoid, five-loculed, syncarpous, whether dehiscent or not is uncertain, but if dehiscent, probably opening loculicidally by gaping slits, because along the dorsal margins of the locules are strands of fibres. Locules tangentially compressed, lanceolate in transverse section, with the broader end turned towards the axis (Pl. XXI, fig. 7). Pericarp woody, the peripheral coat being thick and formed of radially aligned cells, within which is a mass of coarse, irregular, parenchyma filling the angles between the locules. A few fibres appear to be embedded in the parenchyma. The locules appear to be lined by a thin coat of fine fibres longitudinally aligned along their ventral edges, but how aligned over the rest of the surface we do not know. There appears to be a thin axis which is continued for about one-third the length of the fruit, where short funicles appear to be given off towards the locules. Above the top of the axis the bundles which form the ventral margins of the locules are clustered together so as to give a false impression of a continuation of the axis (Pl. XXI, fig. 8). Length of fruit, 7 mm.; diameter, 6 mm.; greatest breadth of locule, 3 mm.; least breadth, 0·75 mm.

Remarks.—One specimen, slightly broken at the apex so that three locules and part of the carpel wall were exposed in transverse and oblique section. We attempted to fracture the fruit longitudinally, but it broke irregularly, and did not release one of the locule-casts and expose the structure of the locule-lining. A second attempt was made to free another locule-cast, but the specimen resisted every artificial attempt to separate the cast from the surrounding carpel, as it had already resisted the natural attempt by battering and abrasion. We have not previously met with locule-casts so closely cemented to the carpel. It was only along the ventral margins, and at the apex, and in minute patches here and there, that we could see the fibres which either line the locule or lie immediately beneath the lining.

Affinities.—There are certain resemblances between this fruit and the fruits of some of the Ternstroemiaceae, *e.g.* *Gordonia* Ellis, *Stuartia* Linn., which are frequently five-loculed and dehisce by gaping loculicidally, thereby releasing the flat, winged, or unwinged seeds. The locules, as in the fossil, are much compressed tangentially, so that the intervening carpel wall is wedge-shaped in section. This wall is formed of a peripheral coat, the exocarp, the cells of which in *Stuartia* are formed of parenchyma, not of cells radially aligned as in the peripheral layers of the fossil. Within is a mass of coarse parenchyma, wedge-shaped in transverse section, which fills the interspaces between the locules. Beneath the locule-lining, which is formed of large, irregular, polygonal cells, and closely adhering to the parenchyma, there is a coat of longitudinal fibres which becomes especially thick where the carpels meet along their ventral margins. In the section Theeae, with which the fossil seems to have most in common, all genera except *Stuartia* have a short median column such as the fossil appears to have, the short funicles arising from its summit. It will therefore be recognized that there are certain resemblances, and certain distinctions, between the fossil and the Ternstroemiaceae, the greatest distinction being the absence from this family, in so far as we know it, of a peripheral coat formed of radially aligned cells, whether in the exocarp or endocarp. We have also compared the fossil with the family Epacridaceae, in which fruits with somewhat similar, and similarly arranged, locules may occur, but the structure of the carpels is quite different, and the fruits of the Epacridaceae are much smaller. The Linaceae, which also have somewhat similar tangentially compressed locules, differ from the fossil in their cell-structure and in the readiness with which they separate into segments both loculicidally and septicidally.

V. 22855 Figured Pl. XXI, figs. 5–8. An imperfect fruit, now fractured to show the structure. *Bowerbank Coll.*, Sheppey.

Family FLACOURTIACEAE

Genus ONCOBA Forsk.

1775. Fl. Aegypt. Arab., p. 103.

Oncoba variabilis (Bowerbank)

PLATE XXI, figs. 9–18.

1840. *Cucumites variabilis* Bowerbank, p. 91, pl. xiii.
1844. *Cucurmites variabilis* Bowerbank (*sic*) : Mantell, p. 178, fig. 42 (1, 3), p. 179, fig. 43 (6).
1859. *Apeibopsis variabilis* (Bowerbank) Heer, pp. 38, 39.
1879. *Apeibopsis variabilis* (Bowerbank) : Ettingshausen (pars), p. 395.
1888. *Apeibopsis variabilis* (Bowerbank) : Schenk, p. 523, fig. 303[5].
1919. *Cucumites variabilis* Bowerbank : Marty, p. 7, fig. 2.

DIAGNOSIS.—Fruit warty, ovoid or globular, one-loculed, many-seeded, with three to ten parietal placentas ; placental mass lobed, seeds lying irregularly within it, sunk in pulp. Length, 8·5 to 28 mm. Seed obovoid, anatropous, hilum and micropyle at the narrow end, chalaza at the broad end. Integuments four, agreeing in structure with those of *O. spinosa ;* length, 3 to 4 mm. ; breadth, about 2·25 mm.

HOLOTYPE.—V. 22856.

NOTE.—In Bowerbank's description of the fruit, which he named *Cucumites variabilis,* he uses the terms pericarp, epicarp, sarcocarp, endocarpal membrane, and placental mass. As we understand his application of the terms to the fossil fruit, the pericarp (cf. Pl. XXI, fig. 9) is the coat of the fruit exterior to the lobed placental mass, which mass is the portion of the fruit most commonly preserved (cf. Pl. XXI, figs. 10–13) ; the epicarp is the peripheral layer of this coat ; the sarcocarp the remainder of the coat, that is the part between the outer layer and the lobed mass ; the endocarpal membrane we have not been able to identify satisfactorily, possibly because of the decayed state of the fossils when they came into our hands ; the placental mass is the lobed mass in which the seeds are embedded. The following description of the pericarp, but not of the placental mass and seeds, is condensed from Bowerbank's description, with additional observations of our own, because, owing to decay of the specimens, our evidence was less complete than his. Bowerbank's observations are usually given in his own words, in inverted commas.

DESCRIPTION.—*Fruit: "Pepo* round or somewhat oval. . . . But in consequence of the extremely succulent nature of these fruits, and their great liability to compression, they vary from this form in every possible degree." Epicarp "thickly studded with minute, elongated, warty excrescences . . . which are sharply carinated, and their greatest length is in the direction of lines at right angles to the axis of the fruit." In transverse section the pericarp shows "an irregular mass of cells ; those nearest the epicarp being very much compressed and distorted, but becoming larger and more definite in their form as they approach the endocarpal membrane." To this we may add that the peripheral cells described are transversely elongate and closely packed, resembling fibres. The large cells appear to form the sarcocarp of Bowerbank, which he states varies in thickness, according to the size of the fruit, from one-third to one-half a line (0·65 to 1 mm.), and is thicker between the placental lobes " since it descends into these spaces and completely fills them up." Within the pericarp lies the placental mass (Pl. XXI, figs. 10–13), the full description of which we defer for the moment, only remarking here that it is conspicuously lobed and furrowed. According to Bowerbank, " the number of lobes presented by sixty-eight fruits is as follows. Two were five-lobed, twenty-two six-lobed, twenty-two seven-lobed, fifteen eight-lobed, five nine-lobed, and two ten-lobed." We ourselves have seen one specimen with three lobes or placentas (V. 22867). The placental mass shows a differentiation between the two ends. At one end the lobes converge on a small, circular, depression enclosed by a rim (Pl. XXI, fig. 10), at the other end they meet in a point (Pl. XXI, fig. 11). Bowerbank calls the former of these areas the base. He further states that " In the specimens which have lost the pericarp . . . the base [is] usually indicated by a small tumid mass." In the only specimen we have seen which showed the placental fibres and thus gave an indication as to which was base and which apex, the preservation was too poor to show the character of the two extremities, but we think it probable that Bowerbank was right in his supposition that the end with the circular rimmed depression represents the base.

Placental Mass: The lobed mass forms a compact body with a tendency to split along the crests of the lobes exposing the seeds dispersed without any order in a pulpy (?) matrix (Pl. XXI, figs. 14, 16). Sometimes the mass splits more irregularly, and sometimes the seeds may be exposed at the exterior by abrasion of the outer surface of the pulp. The peripheral layer (" endocarpal membrane " ?) of the mass is smooth and formed of small polygonal cells, about 0·015 mm. in diameter. In transverse and longitudinal sections the seeds are seen to lie chiefly in perpendicular planes passing through the crests of the lobes and the axis. There are no septa. The placental mass is formed primarily of coarse parenchyma traversed by thick strands of fibres from which the parenchyma radiates. The seeds lie in depressions on a surface formed of larger vermiform, and often much-contorted cells (Pl. XXI, fig. 16). The main fibres, probably associated with the placentas, run longitudinally, close to the periphery and in the neighbourhood of the crests of the lobes (Pl. XXI, fig. 15); they give off branches which traverse the general mass, but do not appear on the surfaces on which the seeds lie. They are seen only rarely, when the mass falls to pieces as the result of decay. Embedded in the substance of the mass are small globular or ovoid (glandular ?) bodies. Length of fruit (according to Bowerbank, 4 to 13½ lines), 8·5 to 28 mm.; breadth very variable according to the degree of distortion, in undistorted fruits usually equal to the length.

Seed: Anatropous, obovoid when uncompressed but sometimes flattened, with a slight mucro associated with the micropyle at the narrow end of the internal cast (Pl. XXI, fig. 17), and a large, circular, depressed chalazal area (Pl. XXI, fig. 18), generally filled by carbonaceous matter at the broad end (hilum of Bowerbank). The cells of all the coats diverge from these two areas. The seed has four integuments. (1) Externally there is a coat (arillus of Bowerbank) formed of cells which superficially are large and polygonal with convex outer ends (Pl. XXI, fig. 16); they are variable in size, and are frequently as much as 0·05 mm. in diameter. Usually the cells themselves have decayed, only their impressions on the pyrites matrix remaining, the external impressions being found on the pyrites between the seed and the placental mass, and the internal impressions on that between this coat and the one next to be described. In one specimen where the actual cells were preserved, the coat appeared somewhat columnar in section, and it was considerably thickened over a longitudinal area (the raphe ?). (2) The second coat, though sometimes carbonized, is frequently preserved merely as an impression. On its external and internal surfaces it is longitudinally striate. Bowerbank says the striae are "the two thousand eight hundred and fifty-sixth part of an inch asunder." It is formed of elongate cells with bevelled ends, at least three or four times as long as they are broad; our measurement of their breadth is 0·015 to 0·016 mm., which corroborates Bowerbank's statement. When partly decayed this coat appears very fibrous and stringy. (3) Next is a thin coat, finely striate transversely (Pl. XXI, fig. 17), and within is (4) the tegmen (testa of Bowerbank) formed of beautiful polygonal or rectangular cells, 0·016 to 0·025 mm. in superficial diameter. Bowerbank gives the average diameter "measured at right angles to the axis of the seed" [*i.e.* to the longest axis], as "the one thousand four hundred and fortieth part of an inch," which does not agree with our measurement. We have seen no trace of an embryo, but Bowerbank states that within the testa [tegmen] there is a nucleus of two cotyledons, covered with a fine reticulated integument, the interstices of which are four-sided. We think it probable that his apparent embryo was the tegmen distorted and partially folded upon itself. Length of seed, 3 to 4 mm.; breadth variable according to the degree of compression, a good typical uncompressed specimen measured 2·25 mm.

REMARKS.—About thirty-six fruits, or placental masses, and numerous dètached seeds and fragments. Bowerbank's specimens were collected in the Island of Sheppey; not in the Isle of Wight as Heer (1859, p. 38), and, following him, Schenk (1888, p. 523) and Marty (1919, p. 1) erroneously state. Bowerbank originally possessed more than seventy specimens; he points out that in some specimens in which the pericarp is preserved, there are few or no traces of the lobes which lie buried beneath it, whereas in other specimens their presence is clearly indicated on the surface. In the latter case he attributes their conspicuousness to "softening of the substance of the pericarp by maceration" previous to fossilization, with resulting contraction of the succulent mass beneath, which fills the spaces between the lobes.

AFFINITIES.—The fruits were regarded by Bowerbank as allied to *Cucumis* (family Cucurbitaceae). Hence his generic name *Cucumites*. Heer subsequently described somewhat similar specimens from the Miocene of Switzerland which may be generically related to Bowerbank's fruits (1859, p. 37). He regarded both as allied to *Apeiba* Aubl. (family Tiliaceae), and referred them to a new genus, *Apeibopsis*. We are of opinion that the Sheppey fruits belong neither to Cucurbitaceae nor to Tiliaceae, but are a species of *Oncoba* (family Flacourtiaceae).

Our reasons for not relating the Sheppey specimens to *Cucumis* are the following:

In the Cucurbitaceae (1) the fruits are much larger, and (2) they show no lobed placental mass with a definite smooth periphery formed of small cells. (3) The disposition of the seeds is much more regular. (4) The seeds have a regular, more or less compressed, bisymmetric form, which is quite different from that of the fossil. (5) There is no chalazal area such as is seen in the fossil. Further, *Cucumis* has a tegmen formed of smaller and much less clearly defined cells, and has no layers in the testa corresponding to those described in the fossil.

Our reasons for not relating the fruits to *Apeiba* are as follows: (1) The fruits of *Apeiba* are covered with stiff spines or closely set large, sharp tubercles in no way resembling the small, scattered "warty excrescences" described and figured by Bowerbank (1840, pl. xiii, figs. 22, 35). Heer's statement is scarcely accurate when he describes the warts seen in the above figures as "dicht stehende, verlängerte Wärzchen." (2) The fruits of *Apeiba* are depressed from base to apex, whereas the fossil fruits are not. (3) The seeds are far more numerous and closely packed in *Apeiba* than in the fossil and are attached to the surfaces of the numerous septa. The septa in themselves constitute a distinguishing feature, for the fossil is without them, but we do not stress this difference because in the living *Apeiba* they may be absorbed when the fruit ripens. (4) The seeds are arranged always with their broad ends turned outwards and the narrow ends inwards, while in the fossil they are oriented quite irregularly. Even such a small semblance of regularity as is seen in Bowerbank's figs. 21 and 34 (1840, pl. xiii) is most exceptional. We have never ourselves met with it. The typical arrangement is that seen in Bowerbank's fig. 20. Heer, however, in order to support his determination, twists the evidence so as to make it appear that regular arrangement is the rule, and irregular the exception. "Bei einem Stück (cf. Fig. 20, von Bowerbank) sind die Samen ohne Ordnung in dieser centralen Masse vertheilt, bei andern aber (cf. figs. 11, 12, 21, 34) scheinen sie in Reihen neben den Nähten zu liegen." Figs. 11 and 12 certainly do not justify any such statement and, as already remarked, neither do figs. 21, 34. Had Heer studied the actual fossil material he would scarcely have so misrepresented the facts. (5) Although the seeds of *Apeiba* are of much the size and shape of the fossil seeds, they really differ considerably from them. The raphe is conspicuous on the ventral face, which it is not in the fossil. The testa is rough externally and formed of exceedingly small polygonal cells. The inner hard coat, columnar in section, is formed of elongate cells, fusiform in superficial view, aligned longitudinally and producing very fine longitudinal striations. There is no inner coat of cells transversely aligned, but the inside of the seed is rough. The tegmen adheres to the testa and does not show the neatly reticulate surface of the fossil.

Our own reference of the fossil to *Oncoba* is based on the following facts. The genus *Oncoba* is characterized by globular or sub-spheroidal fruits, with a hard pericarp, having from two to ten parietal placentas. The numerous seeds are embedded in a pulpy mass which on drying becomes detached from the pericarp. We have been able to study comparatively few species of *Oncoba* but, among those we have seen, *O. spinosa* Forsk. appears most to resemble the fossil. The very few fruits available for examination were globular, with a diameter of about 30 mm. (those of *O. variabilis*, 8·4 mm.—rarely so small—to 29 mm.), the diameter of the placental mass being about 23 mm. (average diameter of *O. variabilis*, 20 mm.). The pericarp is minutely warty, the warts being smaller and closer than those in Bowerbank's illustration. Within the epicarp is a hard coat of transverse fibres as in *O. variabilis*. The placental mass is ridged, not lobed as in the fossil. Splitting occurs along the ridges (along the lobes in *O. variabilis*) and, also, irregularly. The seeds are scattered promiscuously without definite alignment, not only agglomerated beneath the ridges but occurring also between them. The placental mass is formed throughout of parenchyma, finer than that of *O. variabilis*, giving a granular appearance. It is traversed near its periphery by longitudinal bands of fibres which lie beneath the ridges; and sometimes also by median strands along the intercostal hollows. These give off branches which penetrate the whole mass. The seeds are obovoid (or sometimes rather compressed) with a large circular chalaza. The testa is formed, as in *O. variabilis*, of three coats: (1) An outer coat of polygonal cells; (2) a longitudinally striate fibrous coat; (3) a transversely striate coat. The tegmen is formed of small polygonal cells closely comparable with the tegmen cells of *O. variabilis*. The seeds of *O. spinosa* average about 5 mm. in length; those of the fossil about 3 to 4 mm.

When the fruits and seeds of the living and fossil species are thus compared, we think there can be no doubt as to the generic identity of the two.

Oncoba is a genus of shrubs and trees inhabiting Yemen in Arabia, tropical and South Africa, Madagascar, southern Mexico, and South America. *O. spinosa* belongs to the section Euoncoba (Warburg), which is distinguished by its numerous placentas (five or more); it is a native of tropical Africa and Yemen, also reaching Natal.

Previous Records.—In 1757 Parsons (pl. xvi, fig. 16) figured a typical specimen of *O. variabilis* from Sheppey, describing it as "a small melon but uncertain." The same figure was reproduced by Pennant (1801, pl. opp. p. 88, fig. 16).

In 1781 William Jones figured a specimen (pl. v, fig. *c*), describing it as a "sand-box."

Subsequently, in 1810 Crow illustrated Parsons' specimen in his manuscript catalogue (No. 87), and several other specimens were also depicted by him under the following reference numbers: 147, BF, 539, 600, and possibly 209.

In 1859 (p. 37) Heer instituted the genus *Apeibopsis*. In his discussion of its affinities he considers the possibility that the fossils may be allied to one of the following living genera: *Pachira*, *Clusia*, *Garcinia*, and *Oncoba*, but he ends by rejecting the alliance in each case. This is the only reference to *Oncoba* that we have been able to find in palaeobotanic literature. It is possible that Heer's species of *Apeibopsis* should really be referred to *Oncoba*, but they are clearly distinct from *O. variabilis* from Sheppey.

In 1878, Crié (p. 56), in describing a fossil from the Eocene of Sarthe, under the name *Apeibopsis*, refers the Sheppey fruits to this genus in a footnote.

In 1879 Ettingshausen listed (p. 395) without figures or descriptions *Apeibopsis* *variabilis* (Bowerbank). A jar thus labelled in his handwriting contained specimens of Bowerbank's *Cucumites* [*Oncoba variabilis*]. On the same page he also listed *Cucumites sheppyensis* Ett. & Gard. As we have seen no jar so labelled, we do not know whether this was also *Oncoba*.

In 1888 Schenk (p. 523, fig. 303[5]) reproduced two of Bowerbank's figures under the name *Apeibopsis variabilis* Heer.

In 1892 (p. 332) Eck published a new record of *Apeibopsis Laharpii* Heer from the Lower Miocene, followed by a letter (p. 333) from Potonié relating to the fruits in question, in which the writer expressed his opinion that, as Schenk had suggested, *Cucumites* from the London Clay is not necessarily identical with *Apeibopsis* of Heer. Potonié also quoted the opinion of Schumann, with which he agreed, that the systematic position of *Apeibopsis* was doubtful.

In 1904 (pl. lxxx, figs. 120, 128, 148, 152) and 1906 (pl. lvii, figs. 16, 17) Perkins referred fruits from the Brandon lignites of Vermont, U.S.A., to *Apeibopsis*, but judging by his figures and descriptions, they bear no relationship to the Sheppey fruits ; they appear to be loculicidal fruits with a single seed in each locule. Further, *Cucumites Lesquereuxii* Knowlton (in Perkins, 1904, fig. viii, nos. 3, 4, 5, pp. 185, 211) is not *Cucumites* Bowerbank, as evidenced by Knowlton's cross-section.

In 1919 Monsieur P. Marty described a fruit from the middle Oligocene of Lezoux (Puy-de-Dome) which he referred to *Cucumites variabilis*. He gave an account of previous published work on the genera *Cucumites* and *Apeibopsis*, but made no further contribution as regards the living relationship of these plants.

V. 22856 Holotype, figured Bowerbank, 1840, pl. xiii, figs. 11, 12. A placental mass abraded, showing some of the seeds.

V. 22857 Figured Pl. XXI, fig. 9. Half of a fruit, with part of the pericarp preserved, broken longitudinally and showing the seeds within.

V. 22858 Figured Pl. XXI, fig. 10. A placental mass. The specimen shows the circular scar at one end.

V. 22859 Figured Pl. XXI, fig. 11. A second placental mass, figured to show the opposite end to that seen in fig. 10.

V. 22860 Figured Pl. XXI, fig. 12. A placental mass partly covered by remains of the pericarp. Also figured Bowerbank, 1840, pl. xiii, figs. 28, 29.

V. 22861 Figured Pl. XXI, fig. 13. An abnormally small placental mass.

V. 22862 Figured Pl. XXI, fig. 14. A segment of a fruit, showing the seeds lying in the pulpy matrix. V. 22862*a*. A few more segments of the same fruit.

V. 22863 Figured Pl. XXI, fig. 15. A fruit, now rapidly disintegrating ; it shows the fibres associated with placentation.

[The specimen figured Pl. XXI, fig. 16, has disintegrated.]

V. 22864 Figured Pl. XXI, fig. 17. A seed showing micropyle, chalaza, and inner layers of the testa.

V. 22865 Figured Pl. XXI, fig. 18. The chalazal end of a seed-cast. The specimen is figured to show the large chalaza scar.

V. 22866 A placental mass, figured Bowerbank, 1840, pl. xiii, figs. 26, 27.

V. 22867 A fruit, with part of the pericarp preserved, with three placentas.

V. 22868 A few well-preserved seeds.

V. 22869 Twenty-one fruits and numerous segments and fragmentary pieces of placental masses. Also (V. 22869*a*) numerous isolated seeds from the broken fruits.

All the above specimens were labelled by Ettingshausen "*Apeibopsis variabilis* Bow. sp." *Bowerbank Coll.*, Sheppey.

V. 22870 Five fruits and various fragments, labelled by Ettingshausen "*Cucumites variabilis*." *Bowerbank Coll.*, Sheppey.

V. 22871 A small fruit, broken to establish its identity. *Reid & Chandler Coll.*, Minster, 1929.

Genus ONCOBELLA nov.

Diagnosis.—Fruit globular, six-carpelled, one-loculed, dehiscing by valves, many-seeded, with six parietal placentas, seeds not sunk in pulp; length, 7·5 mm.; diameter, 8 mm. Seed, as in *Oncoba variabilis;* length, 2 mm.; breadth, 1 mm.

Genotype.—*O. polysperma* n. sp.

Oncobella polysperma n. sp.

Plate XXI, figs. 19–24.

Diagnosis.—That of the genus.

Holotype.—V. 22872.

Description.—*Fruit:* Globular, syncarpous, six-carpelled, one-loculed; seeds numerous, closely packed and faceted by mutual pressure (Pl. XXI, figs. 19–22), placentation parietal. The dorsal wall of the fruit is largely abraded; only a portion of one carpel remains and six strong longitudinal ribs which run from the base to the apex and appear to delimit dorsal valves (Pl. XXI, figs. 19, 20, 22). In transverse section, each of these ribs appears nearly circular. They are formed of parenchyma with embedded fibres, and there is a marked tendency for the cells to be oriented transversely. Among them there are a few large sclerenchymatous cells which were probably originally pulpy. At the base of the fruit there is a hollow marking the attachment (Pl. XXI, fig. 20). Length of fruit, 7·5 mm.; transverse diameter, 8 mm.

Seed: When not distorted by pressure of other seeds, obovoid, anatropous, with a large circular chalaza at the broad end and the micropyle at the narrow end (Pl. XXI, figs. 23, 24). The integuments of the seed are as follows: (1) An outer coat of rather coarse polygonal cells about 0·033 mm. in diameter. These cells show a tendency to be somewhat elongate longitudinally. (2) A coat, finely striate longitudinally, formed of long, narrow cells, at least on the external surface. These vary considerably in size, a few being 0·01 mm. broad, but the majority much narrower, about 0·008 mm. and a few as narrow as 0·006 mm. (3) An inner coat, finely striate transversely, of elongate cells. (4) The tegmen, formed of hexagonal, or polygonal, equiaxial cells which diverge from the micropyle and chalaza, where they also form concentric rings. The cells of the tegmen are about 0·016 to 0·025 mm. in diameter. Length of seeds, about 2 mm.; breadth, about 1 mm.

Remarks.—One fruit, showing the six ribs above described with the closely packed seeds occupying the intervening spaces, the seeds having been exposed at the surface by the removal of the carpel wall between the ribs, either before fossilization or, perhaps, after fossilization, by abrasion. The regular oval form and smooth margins of the spaces between the ribs from which the pericarp has been removed suggest that valves may have come away. Most of the seeds seen at the surface are so worn that the testa has disappeared exposing the worn pyrites cast of the seed-cavity, but a few seeds showed the micropyle and chalaza and fragmentary remains of the testa. On fracturing the fruit, the closely packed seeds, with testa preserved, were seen filling the locule. There was scarcely any remains of pulp as in *Oncoba variabilis*, but, instead, the seeds were so closely packed together as to occasion considerable mutual distortion (Pl. XXI, fig. 22). In spite of this fact, however, a film of pyrites had penetrated between them, and had hardened during fossilization, producing the effect of " pockets " each containing a seed. No traces of any septa or axis have been seen in the cavity of the fruit.

AFFINITIES.—The general structure of the fruit and seed is similar to that of *Oncoba variabilis*, but there are marked differences between the two species. *Oncobella polysperma* is much smaller ; the abraded carpel wall shows well-defined rounded longitudinal ribs not seen in *Oncoba variabilis*. The seeds are not immersed in a mass of pulp. They are much smaller, relatively more numerous, and more closely packed, and consequently they are much more distorted from their original obovoid form. The seed-coats are, however, identical in their sequence and general character, although the cells of the successive layers are finer in *Oncobella* than in *Oncoba*, except those of the tegmen, which are approximately the same size in both.

There can be no doubt that the fruit belongs to Flacourtiaceae, and is closely related to *Oncoba*. Nevertheless, it is unlikely that it should be referred to the living genus, because, in addition to the differences just described, we have not seen any hint of valves delimited by ribs. On account of these differences we have instituted a new genus for the fossil, and to mark the relationship to *Oncoba* have named it *Oncobella polysperma*.

V. 22872 Holotype, figured Pl. XXI, figs. 19–22. A fruit, now fractured longitudinally to show the locule and seeds. *Bowerbank Coll.*, Sheppey.

V. 22872*a* Figured Pl. XXI, fig. 23. A seed, detached from the holotype. Figured to show the general form, and the small mucro which marks the micropyle.

V. 22872*b* Figured Pl. XXI, fig. 24. A second seed, from the holotype. Figured to show the chalaza.

V. 22872*c* A third seed, from the holotype, much distorted but with well-marked micropyle.

Family HALORAGACEAE

Genus HALORAGICARYA nov.

DIAGNOSIS.—Fruit a four-loculed, conical, ovoid drupe (?). Locules elongate, sausage-shaped, passing at the apex into filiform canals. Length, 3·5 mm. ; length of locule-cast, 2 mm. ; diameter of locule, 0·6 mm.

GENOTYPE.—*H. quadrilocularis* n. sp.

Haloragicarya quadrilocularis n. sp.

PLATE XXI, fig. 25.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22873.

DESCRIPTION.—*Fruit:* Four-loculed, syncarpous, the locules sausage-shaped and placed at the angles of a rectangle with their longer axes vertical. They are arranged in two pairs, the members of each pair closely adjacent to one another, but the pairs themselves are separated by masses of structureless pyrites, which may occupy spaces originally filled with loose tissue. The apex of the fruit is conical; it is penetrated by filiform canals connected with the locules, possibly micropylar or funicular canals.

There are three integuments. The outer, which is the thickest, is formed of coarse parenchyma several cells thick. This coat, although now preserved only between the locules, must have covered them, for its cells, as well as those of the succeeding coats, are impressed upon the locule-casts (perhaps more truly seed-casts). The next coat within is formed of uniform small polygonal cells (0·02 mm. in diameter) which give a finely tessellated smooth surface to the locule-cast where the impressions of its cells are preserved; and within this is a close smooth layer formed of minute, equiaxial, uniform cells (0·01 mm. in diameter) arranged in rows, and with their lateral walls thickened, so that they give rise to delicate striations aligned obliquely near the apex but longitudinally below. Length of fruit, 3·5 mm.; length of locule, 2 mm.; diameter of locule, 0·6 mm.

REMARKS.—One specimen, found by ourselves at Minster in 1929. In order to discover, if possible, the arrangement of the seed and the character of the testa, we attempted to remove one of the locules, but the specimen fractured obliquely across three of the locules without showing any indication of seeds. The fruit was flattened laterally in fossilization, but asymmetrically, so that instead of one pair of locules being flattened on top of the other, it was shifted sideways so that the two pairs now lie almost in the same plane side by side. But the section shows clearly, by the relative positions of the two locules forming each pair, and the lie of the carpel wall between the pairs, that this form is not original, but is due to distortion. We next sectioned the conical apex in order to discover what its relation to the rest of the fruit might be, as we were uncertain whether it was the base or the apex. The resemblance to some of the Haloragaceae led us to believe that it might be the apex, and that the filiform canals which traverse its length (one seen arising from one of the locules) were micropylar or funicular canals. The conical apex itself is now formed of a mass of shining granular pyrites such as frequently replaces loose tissue in Sheppey fossils, the filiform canal being filled with fine grey pyrites such as constantly fills cavities.

AFFINITIES.—There are but few families to which this small four-loculed fruit could be referred. The two most probable would appear to be the Saxifragaceae (sub-family Hydrangioideae) and the Haloragaceae. After closely considering the possibility of the Saxifragaceae (on this interpretation the conical end would represent the base of the fruit) we were obliged to discard any idea of such a relationship, since the carpellary coats are of quite a different character from those of this family. These are thin, dry, and papery, and have none of the large cells seen in the fossil. The Haloragaceae show more numerous points of resemblance. Several species among the genera *Haloragis* Forst., *Myriophyllum* Ponted. ex L., and *Proserpinaca* Linn. are of much the same size, and their locules are similar in shape. The carpels in *Proserpinaca* and *Haloragis* are closely united into a multilocular drupe, three-loculed in *Proserpinaca*, and usually four-loculed in *Haloragis*. In *Myriophyllum* they are more loosely attached by their ventral angles to form a deeply four-lobed drupe, the segments of which are easily separated as cocci in life, and almost invariably separated in fossilization. The arrangement of the endocarp in the fossil seems not to be precisely like that of any of these genera, for although the carpels have remained united, they have been displaced relatively to one another. In *Myriophyllum* and *Proserpinaca* the main thickness of the endocarp wall is formed of coarse parenchyma. In *Haloragis* the external angles between the locules are filled with very large cells, the endocarp walls being formed for the most part of smaller cells which become more compacted towards the locule. The cells are comparable in size with those giving rise to the tessellated surface in the fossil, but whether they could form such a surface we do not know. The locules in all these genera are lined by small equiaxial cells arranged in rows, as in the fossil. It follows, therefore, that the structure of the carpel walls in species of Haloragaceae, more especially in *Haloragis*, is quite comparable with the structure of the carpel wall in the fossil. In *Haloragis*, and to a lesser extent in *Proserpinaca*, the top of the fruit is conical, the radicular end of the seed being attenuated into the stylar canal which passes upwards through the surrounding loose, stringy tissue, or empty space of the conical apex of the fruit. The chief difficulty in referring the specimen to Haloragidaceae arises from the mode of germination in the family. *Haloragis*, *Proserpinaca*, and *Myriophyllum* all germinate through a large apical aperture which is closed either by thin or by soft tissue. We have seen no such definite aperture in the fossil, but in breaking the conical apex, the top of one of the locule-casts was exposed, the tops of the other three remaining buried in the pyrites of the cap. This locule-cast everywhere shows the impression of the smooth surface of the locule, except on its inner face at the apex. Here the smooth surface of the locule-cast, on which are the impressions of the cells of the locule-lining, terminates against a patch which in part has a finished edge; within this patch, over an extent not exactly known, the pyrites which forms the locule-cast passes uninterruptedly into the pyrites of the cap. Such continuity implies that at this point the locule and the hollow apex were connected. That is to say, that in this position there appears to have been an aperture leading from the locule to the hollow apex. If this apparent fact is a real fact, there can be no hesitation in assigning the fossil to Haloragaceae; and its structure is in every other respect so closely comparable with the structure of the fruits of Haloragaceae that we think it a probable relationship. We have named the fossil *Haloragicarya quadrilocularis*.

V. 22873 Holotype, figured Pl. XXI, fig. 25. A fruit with locule-casts. *Reid & Chandler Coll.*, Minster, 1929.

Family LYTHRACEAE

Genus MINSTEROCARPUM nov.

Diagnosis.—Fruit a sub-cylindric loculicidal capsule, four- to six-loculed, placentation axile, seeds numerous, attached horizontally in two rows in each locule. Length, 16 to 22 mm.; breadth, 4 to 8 mm. Seed sickle-shaped to semicircular in outline, narrowly cuneate in transverse section, twisted spirally through an angle of 90°, with a club-shaped body margined by a coriaceous wing, anatropous. Length, 3 to 3·5 mm.; breadth, 1·75 to 2 mm.; width of thick margin, 0·5 to 0·75 mm.

GENOTYPE.—*M. alatum* n. sp.

Minsterocarpum alatum n. sp.

PLATE XXI, figs. 26–31; text-fig. 15.

1879. *Corchorites quadricostatus* Ettingshausen, p. 395.
1879. *Corchorites quinquecostatus* Ettingshausen, p. 395.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22874.

DESCRIPTION.—*Fruit:* Syncarpous, usually four-loculed, sometimes five- or six-loculed, sub-cylindrical, sometimes narrowed towards the apex, longitudinally furrowed both between the locules and along their median lines, the former set of furrows much wider and deeper than the latter. The fruit was apparently a loculicidal capsule, for a narrow longitudinal ridge of pyrites down the middle of the locule-cast (Pl. XXI, fig. 27) suggests that dehiscence had begun, allowing the infiltration of pyrites into the incipient fissures. Placentation axile, the seeds being attached horizontally in two longitudinal rows to a thick fibrous axis (Pl. XXI, figs. 27, 28). Septa, as seen in transverse section, formed of loose large cells; locule-lining formed of several differently oriented layers of fine fibres, the superposed impressions of which produce a criss-cross effect; on the dorsal surface of each locule these fibres diverge obliquely from the median line. Thick cords of longitudinal fibres lie in the grooves between the locules. Length of fruit, 16 to 22 mm.; breadth, 4 to 8 mm.

Seed: (In describing this seed, we use the terms "upper surface" for that turned towards the top of the fruit, and "lower surface" for that turned towards the base of the fruit.) Seed slightly sickle-shaped, or sub-triangular, or semicircular in outline, compressed, but not flat, the lateral faces being twisted spirally through an angle of about 90° (Pl. XXI, figs. 27, 28), narrowly sub-cuneate in transverse section, the external face (*i.e.* the curved face turned towards the outside of the fruit) being faceted against the lateral faces; the face is broader towards the base, or proximal end of the seed, than towards the apex, or distal end (Pl. XXI, fig. 30). It is this faceted and twisted face which is seen in Pl. XXI, figs. 27, 28, where the seeds are in place, and on the right hand of the isolated seed (Pl. XXI, fig. 30). The inner margins of the seeds are thin, although also twisted; it is these which are in contiguity in the two rows of seeds in each locule. The seed has a somewhat club-shaped body, oval in section, and a stiff, thick, wing-like rim (Pl. XXI, fig. 30; also text-fig. 15); it is anatropous, with the hilum terminal at the narrow end of the seed-body (proximal end of the seed; base in Pl. XXI, figs. 30, 31) and the chalaza, flat, circular, and black, terminal at the broad end. Testa formed of the following coats: (1) An external coriaceous coat, very thin, of coarse very irregular cells, as seen in surface view; on the lower side of the seed, over the seed-body, these cells are drawn out so as to produce the effect of nerves (Pl. XXI, fig. 31) which diverge upwards ; elsewhere the cells diverge from the body to form a coarse network over the wing (Pl. XXI, fig. 31). On the upper surface of the seed the cells are finer, diverging from a longitudinal line marking the position of the body. (2) Within this coat is a second, formed of spongy tissue two or three cells thick on the lower surface of the seed, but absent over the body of the seed on the upper surface, so that the coriaceous coat easily tears away in this region (as in Pl. XXI, fig. 30). In the wings of the seed, this spongy coat thickens greatly and forms the mass of their substance (text-fig. 15). The cells are very irregular in size and shape, varying from about 0·016 to 0·05 mm. in diameter ; in some cases they may even exceed these dimensions. (3) A carbonaceous coat, one cell thick, formed of large, inflated, or polygonal cells of relatively uniform shape and size arranged in longitudinal rows. The cells are about 0·016 to 0·025 mm. in diameter. The coat itself may be preserved, or its impression only may be seen obscurely on the pyrites-cast of the seed-cavity. (4) A delicate, thin coat, the tegmen, formed of elongate cells, about 0·008 mm. broad, giving a longitudinally striate effect. The conspicuous chalazal scar is associated with this coat, which is separated from

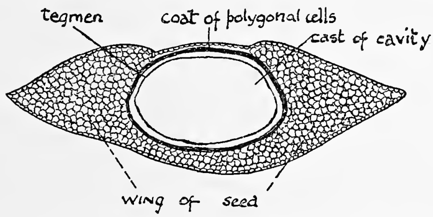


FIG. 15.—Transverse section across a seed of *Minsterocarpum alatum*.

the last (3) by a film of pyrites. Length of seed, about 3 to 3·5 mm. ; breadth, 1·75 to 2 mm. ; breadth of thick margin, 0·5 to 0·75 mm.

REMARKS.—Four complete, and several imperfect and fragmentary fruits. Two of these, one perfect and one imperfect, were collected by ourselves at Minster. The remainder belong to the Bowerbank Collection and are in a soft and disintegrating condition. We were able, fortunately, to obtain a few photographs of them before they fell to pieces. In all specimens the pericarp is more or less completely abraded, so that the exterior of the fruit has never been seen, and the mode of dehiscence can only be inferred. Fine-grained pyrites has filled all the interstices in the carpels, penetrating between the seeds so as to form a cement which has bound the seeds of each locule into a solid mass, and kept the carpels united. Consequently, when the carpel wall fell away or decayed the locules and seeds remained in position. But, since pyrites itself is liable to decay on exposure to the air, all the specimens, when so exposed, tend to disintegrate by splitting into separate blocks of seeds, and by splitting further into segments containing only a few seeds. Pyrites has also penetrated into the seeds themselves, forming thin layers or films between any two adjacent coats, so that seed-coats and pyrites films alternate.

Consequently, when an attempt is made to separate the seeds from one another, the fracture is irregular and may pass either between two seeds or between a seed-coat and a layer of pyrites in the same seed, or between different layers in different parts of the same seed. It must further be remembered that each layer of pyrites bears on its surface the impression, and possibly some of the carbonized remains, of the adjacent seed-coats. Only by the most careful study of many seeds in section —in itself a difficult process on account of their brittle character in the fossilized state—could the succession of coats be disentangled.

Affinities.—These fruits were originally in a jar labelled by Ettingshausen "*Corchorites* sp. 1." They probably represent the *Corchorites quadricostatus* and *C. quinquecostatus* of his published list (1879, p. 395), as four- and five-loculed forms were mingled in the bottle. Since the fruits with their closely packed seeds in two rows bear a superficial resemblance to *Corchorus* (Tiliaceae), we made a close comparison with the fruits and seeds of that genus. There is indeed a slight resemblance between the anatropous living and fossil seeds in the two cases. But the seeds of *Corchorus* are thicker and more angular, and are not flattened in the same degree as are those of the fossil; also they have no hint of the wing or of the twist on the seed, both of which are such conspicuous features of the fossil. We were therefore obliged to search elsewhere for the true relationship. In so doing we discovered that few families show a similar arrangement of seeds in the capsule combined with a variable number of from four to six locules. These characters do occur in certain genera of the family Tiliaceae, but none of these genera corresponds in its other features with the fossil, more especially, the seeds are not winged and twisted. The only genus we have found with comparable seeds is *Lagerstroemia* Linn. of the family Lythraceae, in which family the characters of the fruit also occur, but in *Lagerstroemia* itself the capsules are either globular or ovoid, and are often very large, with persistent calyx. The seeds are stiffly winged, and closely packed one above the other in two rows, but the rows are much shorter than those in the fossil. In most species the seeds also differ in shape from those of the fossil, being more elongate, but the seeds of *L. intermedia* Koehne are very similar, with a faceted external (dorsal) margin, which shows a spiral twist. Again, as in the fossil, the club-shaped body occupies the middle part of the seed between the stiff wings. Externally the wings are covered by an integument formed of coarse long cells which constitute the outer layer of the testa, the cells diverging from the body of the seed so that at the apex they are aligned longitudinally, as in the fossil. Within this integument, parenchyma forms the substance of the coriaceous wings; it is thick in the wings themselves, but thin over the upper and lower surfaces of the body, just as in the fossil. On its inner surface, where it adjoins the body, it is formed of large regular polygonal or hexagonal cells. A comparison with the description of the fossil seed will show that these integuments which form the wing of *Lagerstroemia*, and which we were able to study in detail in the seeds of *L. flos-regina* Retz, correspond extremely closely with the first three integuments of the fossil seed. In the living *Lagerstroemia* they are followed by a striate layer, which can only be separated from the wing with great difficulty; then follows a coat of white elongate cells, within which is the tegmen, thin and finely striate as in the fossil. Thus while the wing integuments and the tegmen are in close correspondence in the fossil and in the recent *Lagerstroemia*, the intermediate striate coats which cover the body of the living seed are wanting in the fossil. Whether they were ever present there is no evidence to show. The position they would have occupied is now taken by structureless pyrites which has infiltrated between the remaining integuments and the tegmen. Nevertheless the above evidence taken in connexion with the form of the seeds in *L. intermedia* and with the fact that the position of hilum and chalaza is the same, also the character of the chalaza and its association with the tegmen, leaves little doubt that the London Clay plant must be referred to the family Lythraceae, and must have been nearly related to *Lagerstroemia*. The larger, more globular fruits of the living genus, and the fewer number of seeds, makes it necessary to place the fossil in a distinct genus. We have named it *Minsterocarpum alatum*.

Lagerstroemia is a genus of trees and shrubs inhabiting the tropics of the old world, except Africa. It abounds in India, China, extending also to Japan, the Philippines, Andamans, East Indies, Australia, and Madagascar.

V. 22874 Holotype, figured Pl. XXI, fig. 26. A four-loculed fruit with external walls of the carpel abraded. *Reid & Chandler Coll.*, Eastchurch, 1928.

V. 22875 Figured Pl. XXI, figs. 27, 30, 31. A four-loculed fruit, now fallen to pieces by disintegration of the pyrites which acted as a cement between the seeds (exposed at the surface by abrasion of the external walls of the carpel). A seed from this fruit, figured (fig. 31) to show the lower surface. A second seed, figured to show the upper surface (fig. 30). A few seeds, unfigured.

V. 22876 Figured Pl. XXI, fig. 28. A fruit, abraded so that not only are the carpel walls removed but the bodies of the seeds are also partially exposed.

V. 22877 Figured Pl. XXI, fig. 29. A broken fruit, figured to show the apex, with four carpels and remains of carpel walls between them.

V. 22878 A fruit, now in fragments.

V. 22879 An imperfect abraded fruit. *Reid & Chandler Coll.*, Minster, 1929.

Unless otherwise stated, the above are from the Bowerbank Coll., Sheppey.

Genus PACHYSPERMUM nov.

DIAGNOSIS.—Fruit a sub-cylindric septicidal capsule ?, five-loculed, placentation axile, placentas prominent. Seeds numerous in many rows in each locule, attached horizontally. Length, 26 mm. + ; diameter, 8 mm. Seeds oblong, inflated, longitudinally divided into a cylindrical seed-body and thick lateral appendage (raphe ?), anatropous. Length, 1·3 to 1·5 mm. ; breadth, 1 mm. ; diameter of seed-body, 0·5 mm.

GENOTYPE.—*P. quinqueloculare* n. sp.

Pachyspermum quinqueloculare n. sp.

PLATE XXII, figs. 1–7.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22880.

DESCRIPTION.—*Fruit:* Sub-cylindric, tapering at one end (the other end incomplete), syncarpous, septicidally capsular (?), five-loculed, with numerous seeds attached to prominent axile placentas (Pl. XXII, fig. 2). Inner layers of the endocarp formed of markedly transverse fibres or cells, visible over the septa and the adjacent part of the carpels (Pl. XXII, fig. 5), elsewhere worn away with the rest of the pericarp. Length of fruit (broken at apex ?), 26 mm.; diameter, 8 mm.

Seeds: Oblong, inflated, more or less faceted by mutual pressure, conspicuously divided longitudinally into two parts, the smaller being the seed-body and the larger a spongy lateral appendage which partly embraces the sub-cylindric seed-body (Pl. XXII, figs. 3–7). The appendage is formed by a mass of parenchymatous cells (0·016 to 0·025 mm. in diameter) and is obviously associated with the raphe, but we were unable to determine the exact manner of this association. Anatropous, with hilum basal at the proximal end of the seed, and chalaza, a conspicuous circular scar, sub-apical at the opposite end between the body and lateral appendage. Pl. XXII, fig. 7, shows the chalaza on a seed-body from which the appendage has been detached. Testa formed of two coats. A thin net-like outer coat formed of large loose cells (0·015 to 0·016 mm. broad and often three times as long) aligned transversely or obliquely. This coat covers the whole seed, including seed-body and lateral appendage. It is usually represented merely by the impression of its outer surface on pyrites (Pl. XXII, fig. 4). The inner coat is formed of fine longitudinal fibres which converge towards the micropyle and chalaza (Pl. XXII, fig. 6). This coat is usually carbonized. The tegmen is smooth, finely striate longitudinally. The cells forming it are rather obscure, being preserved only as impressions on the seed-cast. Length of seed, 1·3 to 1·5 mm.; breadth, including seed-body and appendage, 1 mm.; diameter of seed-body, 0·5 mm.

Remarks.—One incomplete fruit. The preservation of this beautiful specimen is exactly comparable with that of *Minsterocarpum alatum* n. sp. just described, the pericarp having perished. The five locule-casts with included seeds have remained united, except at one end (Pl. XXII, fig. 1) which, for reasons to be explained, we believe to be the apex. At this end all the locule-casts are broken across, the upper portions being lost, but one of the casts was at first less broken, and projected beyond the others, showing on its lateral faces the smoothly finished septa. This indicates that dehiscence was septicidal, and suggests that at this end the capsule gaped septicidally, and that the locule-casts in consequence also gaped apart, and were easily broken. If so, then this end was probably the apex. The projecting locule-cast subsequently broke away. The cross-section of the fruit shows the prominent placentas with seeds attached protruding into each locule (Pl. XXII, fig. 2). In its present abraded state the fruit is lobed at the base, which, except for the loss of the pericarp, is perfect. The lobing, in part, doubtless represents the form of the locule-casts, but it is exaggerated by differential decay between the partly carbonized septa and the hard pyritized locule-casts. The softer septa have been worn away, leaving the locule-casts projecting; over the middle of the fruit there is no hint of lobing. Plate XXII, fig. 1, shows well both the lobing caused by the wearing of the septa below and the less-worn septa above; it also shows the seed-casts lying within the worn locule-casts.

Affinities.—So much information is available about this fruit, and its remains are in such a good state of preservation, that it has been possible, as in the case of many of the Sheppey fruits, in determining the affinities, to make use of ordinary botanical classifications without having recourse to the much more laborious method of exhaustive detailed comparison of all possible forms. The five-loculed, almost certainly septicidal, capsule, having anatropous seeds with swollen raphes attached to prominent axile placentas, confines the possible relationship to a very few families. The Ericaceae, section Rhododendroideae, the Sarraceniaceae, and the Lythraceae alone have such fruits and seeds. The Rhododendroideae have in many cases similar fruits of the same size, but the seeds are very small and differently marked, and are usually winged circumferentially, or else the raphe is produced into a fringe or tag at each end. In the group Triflora there are seeds without tags or wings which in shape more resemble the fossil, but the raphe is not swollen.

The Sarraceniaceae also have a much smaller raphe than the fossil. *Sarracenia* Linn. itself is the most comparable member of the family, but again it has a relatively small raphe and its surface is tubercled.

There can be no doubt that the relationship really lies with the Lythraceae, in which family not only do five-loculed capsules with prominent axile placentas and numerous small seeds occur, but the seeds commonly have a spongy thickening of the testa, sometimes symmetrically, sometimes asymmetrically placed. We are not able, however, to assign the fossil to any living genus; nor can we determine to which living genera of the family it is most closely allied.

V. 22880 Holotype, figured Pl. XXII, figs. 1–7. A fruit, broken at one end (apex ?) with the dorsal walls removed by abrasion so that the seeds are exposed.
V. 22880*a* A group of seeds from one of the locules figured Pl. XXII, fig. 4, to show the arrangement of the seeds, and the seed-coats.
V. 22880*b* An isolated seed figured Pl. XXII, fig. 6, to show the body and thickened raphe.
V. 22880*c* The thick raphe of a second isolated seed; body of this seed (now decayed) figured Pl. XXII, fig. 7, to show the chalaza.
Bowerbank Coll., Sheppey.

Family LYTHRACEAE ?

Genus TAMESICARPUM nov.

Diagnosis.—Fruit an ovoid loculicidal capsule, three- to six-loculed, placentation axile. Seeds numerous, erect, arranged in two to four rows in each locule. Length, 9 to 15 mm.; diameter, 9 to 13·5 mm. Seeds semi-oval in outline, subtriangular in section, anatropous. Outer coat of testa formed of long cells (0·3 to 0·4 mm. × 0·1 mm.) aligned perpendicularly to the surface. Length, 3·5 mm.; dorsiventral diameter, 1·8 to 2 mm.; breadth of dorsal margin, 1·5 mm.

Genotype.—*T. polyspermum* n. sp.

T. polyspermum n. sp.

1879. *Juglans eocenica* Ettingshausen (pars), p. 394.

Plate XXII, figs. 8–21.

Diagnosis.—That of the genus.

Holotype.—V. 22881.

Description.—*Fruit:* Ovoid, capsular, syncarpous, three-, four-, five-, or six-loculed, dehiscing loculicidally. The thick outer coat (as preserved) is formed of parenchyma; near its periphery are embedded wide, flat, longitudinal bands of fibres; the locule-lining is formed of fibres aligned transversely. The locules are many-seeded, with at least ten erect seeds in each; these may be arranged more or less regularly in two, three, or four rows (Pl. XXII, figs. 9, 12, 13, 17). Placentation axile (Pl. XXII, fig. 9). Length (as preserved) of a well-developed fruit, 15 mm.; diameter (as preserved), 13·5 mm. Length of smallest fruit, 9 mm.; breadth, approximately 9 mm.; greatest width of the dorsal face of the locule-cast in a typical specimen, 4·5 mm.; radius of the same from axis to surface, 4 mm.

Seeds: Semi-oval in profile, narrower at the base than at the apex, and sub-triangular in section, anatropous, with hilum and micropyle at the narrow end, the small chalaza almost terminal at the broad end, and raphe on the ventral angle. Testa thick, formed of two coats; the outer coat, one-cell thick, is formed of large cells arranged at right angles to the surface of the seed (shorter over the raphe), hexagonal and inflated in surface view, the hexagons tending to be aligned in longitudinal rows on the lateral faces (Pl. XXII, fig. 20); superficial diameter of cells, 0·3 to 0·4 mm.; depth, 0·1 mm. The inner coat of the testa is formed of fine parenchyma. The tegmen is formed of angular cells with transversely parallel sides (Pl. XXII, fig. 19), which give rise to transverse striations forming a series of concentric rings around the micropyle and chalaza; they measure about 0·025 mm. by 0·025 to 0·05 mm. Length of seed, 3·5 mm.; dorsi-ventral diameter, 1·8 to 2 mm.; breadth of dorsal margin, about 1·5 mm.; length of seed-cavity, 2·4 to 3 mm.; breadth, 1·2 to 1·5 mm.; thickness, 0·8 mm.

Remarks.—Twenty fruits, usually with the pericarp more or less completely abraded, and a few detached carpels. One specimen (Pl. XXII, fig. 10) shows the remains of a peduncle, and thereby gives information as to which is the base and which the apex of the fruits. The bulk of the specimens are merely the pyritized casts of the locules which have remained adhering to one another and to the axis. The lobed appearance of these specimens is due to the decay of the septa between the locule-casts, which leaves the latter standing out (Pl. XXII, figs. 13–17). Many of the casts have a fine median longitudinal ridge of structureless pyrites on the dorsal surface which is the evidence for loculicidal dehiscence, because it indicates incipient fissures into which pyrites infiltrated (Pl. XXII, figs. 10, 11).

The seeds were evidently very tightly packed within the locules, for the locule-casts frequently show a mosaic pattern on their surface, corresponding to the outlines of the seeds (Pl. XXII, figs. 9, 12, 13, 17). Two specimens (Pl. XXII, figs. 8, 9, 18–21) have the seeds themselves preserved; in these each cell of the testa is filled with pyrites; the seed-cavity also is so filled, so that on the surface of the seed-cast the impressions of the micropyle, chalaza, and tegmen-cells are all clearly preserved.

Affinities.—So far as we have been able to carry our observations, the only fruits with two to six locules, loculicidal dehiscence, axile placentation, and numerous seeds in each locule, belong to the family Lythraceae. In this family the seeds are often cuneate or sub-cuneate in form, and they frequently have an outer coat several cells thick formed of very large inflated angular cells with a parenchymatous coat inside it.

In the fossil, however, the outer coat of large cells is only one cell thick, but in all other respects the two coats of its testa are similar to corresponding coats in the seeds of many Lythraceae. But whereas in the fossil the tegmen is formed of angular cells arranged so as to give rise to marked transverse striations, in the Lythraceae the cells of the tegmen are not so arranged, for although they are angular, the striations are less marked and have a general longitudinal alignment. This longitudinal alignment appears at the present day to be of diagnostic value. We are therefore doubtful whether the fossil should be referred to Lythraceae. At the same time we can find no equally close resemblance in any other family. Therefore, we have placed these specimens doubtfully in the Lythraceae, to which alliance the bulk of the evidence appears to point.

V. 22881 Holotype, figured Pl. XXII, figs. 8, 9, 18–21. A fruit with the seeds preserved, and exposed at the surface by the removal of the carpel walls as the result of abrasion. The seeds adhere together owing to a cement of pyrites which has filtered in between them; this cement is now decaying so that the seeds readily fall apart and the specimen is gradually disintegrating.

V. 22881*a* A detached seed from the fruit, imperfect at base and apex, with testa preserved (Pl. XXII, fig. 20).

V. 22881*b* An internal cast of a detached seed (Pl. XXII, fig. 18), showing the ridge associated with the raphe.

V. 22881*c* A second internal cast of a seed from the same fruit showing the transverse arrangement of the tegmen cells (Pl. XXII, fig. 19).

V. 22881*d* Several detached seeds from the same fruit, some with and some without the testa.

V. 22882 Figured Pl. XXII, fig. 10. A fruit (internal cast) with remains of the peduncle.

V. 22883 Figured Pl. XXII, fig. 11. A three-loculed fruit with the carpel walls abraded showing the ridges of pyrites which have filtered in along the lines of loculicidal dehiscence, for which they are the evidence.

V. 22884 Figured Pl. XXII, fig. 12. An internal cast of a fruit with remains of the carpel wall at the base. The mosaic pattern, due to the impression of the seed outlines on the locule, can be clearly seen on the cast.

V. 22885 Figured Pl. XXII, fig. 13. An internal cast of a fruit showing the impressions of the seeds arranged in two rows.

V. 22886 Figured Pl. XXII, figs. 14, 15. A typical cast of a four-loculed fruit.

V. 22887 Figured Pl. XXII, fig. 16. A cast of a rare five-loculed fruit.

V. 22888 Figured Pl. XXII, fig. 17. A cast, now fractured longitudinally, labelled by Ettingshausen "*Juglans eocenica* sp. nov."

V. 22889 The cast of a fruit with some of the seeds preserved.

V. 22890 Eight casts, two with remains of the carpel walls.

V. 22891 Fifteen isolated or broken locule-casts, showing the mosaic impression due to the outlines of seeds impressed upon the locule wall.

All the above are from the Bowerbank Coll., Sheppey.

V. 22892 A cast of a three-loculed fruit. *Reid & Chandler Coll.*, Minster, 1929.

? Tamesicarpum polyspermum

1840. *Cupressinites corrugatus* Bowerbank, p. 61, pl. x, figs. 28, 29.
1845. *Cupressites corrugatus* (Bowerbank) Unger, p. 193.
1847. *Solenostrobus corrugatus* (Bowerbank) Endlicher, p. 8.
1850. *Solenostrobus corrugatus* (Bowerbank): Unger, p. 343.
1879. *Solenostrobus corrugatus* (Bowerbank): Ettingshausen, p. 392.

The type of *C. corrugatus* is no longer extant. Bowerbank gives the following diagnosis and description :

" *Cupula* five-cleft, segments lanceolate, somewhat concave, and corrugated on their outer surface.

" I have seen but one specimen of this species of fruit. The cupula is somewhat depressed in form, fleshy, and divided nearly to the base into five equal segments ; each of which is slightly concave towards the base of the exterior surface . . . and the whole exterior surface of the cupule is very much corrugated. No part of the stalk remains attached to the fruit, but its point of attachment is marked by a small circular area, surrounded by an elevated fleshy ring, . . . Upon cleaving this fruit through its centre in a longitudinal direction, it proved to be filled up with fine granular *pyrites*, and no traces of a placenta, seeds, or organized structure could be detected."

The specimen was clearly a pyrites-cast of a five-loculed fruit. It can have had no connexion with the Cupressineae. In the absence of further information its affinities cannot be discovered, but it is possible that it may have been a rather small depressed specimen of *Tamesicarpum polyspermum*, described above. If this were so and such a relationship could be proved conclusively, *Tamesicarpum polyspermum* would become *T. corrugatum* (Bowerbank). But the relationship is by no means certain. The length of Bowerbank's fruit (taken from the figure) was 10 mm. ; diameter, about 11·5 mm. ; its size would not therefore separate it from *Tamesicarpum*.

Genus CRANMERIA nov.

DIAGNOSIS.—Fruit ovoid. Carpels probably opening loculicidally along their ventral angles after separating septicidally, placentation axile, seeds numerous, attached obliquely. Length, 17·5 to 18·5 mm. ; diameter, 8 to 11 mm. Seed ovate-lanceolate, sometimes slightly falcate. Testa formed of hexagonal cells (0·05 to 0·1 mm. in diameter) arranged in longitudinal rows. Length, 1·75 mm. ; diameter, 0·25 to 0·5 mm.

GENOTYPE.—*C. trilocularis* n. sp.

Cranmeria trilocularis n. sp.

PLATE XXII, figs. 22–28.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22893.

DESCRIPTION.—*Fruit:* Ovoid (a berry ?), three-loculed, carpels opening along the ventral sutures ? after separating septicidally ? Locules long and narrow with numerous seeds lying obliquely (Pl. XXII, figs. 23, 25), attached, in several rows in each locule (Pl. XXII, fig. 24), to long, axile, two-rayed placentas which project far into the locules. Pericarp thick, epicarp not seen, mesocarp formed of coarse rather loose-textured parenchyma in which a few fibres are embedded. The structure of the fruit is much obscured by being impregnated with iron pyrites which has filled all the cells and has frequently obliterated the cell walls. Endocarp (horny ?) formed of an outer layer of small cells arranged in a columnar manner, within which are many layers of fine transverse fibres, the innermost layer, which constitutes the locule-lining, being smooth and polished. The columnar coat of the endocarp tends to decay irregularly, giving it a cavernous appearance. Between the mesocarp and endocarp, associated with the inner layers of the former, are many large lacunae, filled with glistening pyrites. They probably represent glandular cavities. Length of fruit, 17·5 to 18·5 mm. ; diameters (fruit compressed), 8 and 11 mm.

Seed: Small, ovoid-lanceolate, sometimes slightly falcate, anatropous, attached to the axile placentas by the narrow end, at which are the micropyle and hilum. The chalaza, at the opposite rounded end, is a circular scar with a central spot which marks the entry of the raphe. Testa formed of coarse hexagonal cells, 0·05 to 0·1 mm. in diameter, aligned more or less in longitudinal rows (Pl. XXII, figs. 27, 28). Each cell is somewhat inflated towards the exterior, giving a tubercled surface to the testa. Towards the interior the cells must have been concave, for their impressions on the locule-cast produce a tubercled surface. Length of seed, 1·75 mm. ; diameter, 0·25 to 0·5 mm.

Remarks.—Two fruits. One was found by ourselves in 1929 at Minster (Pl. XXII, figs. 22, 26, 27) ; the other, which is in a badly decaying condition, belongs to the Bowerbank Collection (Pl. XXII, figs. 23–25, 28). The latter specimen quickly fell to pieces, breaking longitudinally. Our own specimen, when fractured transversely, also broke longitudinally. The transverse section showed clearly the three locules with bifurcated placentas projecting into them bearing the seeds. These placentas appear to be formed by the incurved margins of the septa. That the fruit was a berry is suggested by the crumpled and partially collapsed mesocarp (Pl. XXII, fig. 22).

The transverse direction of the cells which form the locule-lining, and the fact that the inner edges of the septa do not meet, suggest that after the decay of the fleshy mesocarp the separate carpels gaped loculicidally along their inner angles, thereby releasing the seeds in much the same way as the seeds of *Rhamnus* are released.

Affinities.—The characters which are significant in the diagnosis of this fruit appear to be that it is a three-loculed berry the carpels of which dehisce along the ventral sutures, thus liberating the numerous, obliquely attached, anatropous seeds. Few families have comparable characters, and the Lythraceae perhaps afford the most probable relationship. We have named the species after Cranmer, Archbishop of Canterbury, 1533 to 1556.

V. 22893 Holotype, figured Pl. XXII, figs. 22, 26, 27. A fruit, now fractured to show the seeds. *Reid & Chandler Coll.*, Minster, 1929.

V. 22894 Figured Pl. XXII, figs. 23–25, 28. A fruit, much decayed and broken. V. 22894*a* is an internal cast of a seed from the same fruit, figured Pl. XXII, fig. 28. *Bowerbank Coll.*, Sheppey.

Family ONAGRACEAE

Genus PALAEEUCHARIDIUM nov.

DIAGNOSIS.—Fruit sub-globular, four-loculed with one seed in each locule. Length, 4·5 mm.; diameter, 4 mm. Seed ovate in outline, triangular in section, formed of seed-body lying to the dorsal side, and wing to the ventral side: seed-body obovate in dorsal outline, sub-oval in transverse section; wing, formed of large prismatic cells (0·6 to 0·9 × 0·05 mm.) with their long axes perpendicular to the surface of the seed-body. Length of seed, 4 mm.; breadth of dorsal face, 2·3 mm.; dorsi-ventral thickness, 1·7 mm. Corresponding measurements of seed-body, 2 × 0·6 × 0·3 mm.

GENOTYPE.—*P. cellulare* n. sp.

Palaeeucharidium cellulare n. sp.

PLATE XXIII, figs. 1–4; text-fig. 16.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22895.

DESCRIPTION.—*Fruit:* Sub-globular, four-seeded, the seeds lying in the angles made by four septa diverging at right angles from a large, fibrous axis. The axis forms a short knob-like stalk at the base; the septa are flat, thin, and fibrous, the fibres being aligned longitudinally. Length of fruit (carpel walls abraded) including stalk, 4·5 mm.; breadth, 4 mm.

Seed: Probably anatropous with dorsal raphe; ovate in outline but emarginate at the base; triangular in transverse section (text-fig. 16), the dorsal face being somewhat convex, and the two flat ventral faces meeting at an angle of 90°, so that they exactly fit into the rectangular space between the septa. In transverse section the seed shows a seed-body sub-oval in section with its longer diameter tangential to the surface of the fruit, and a large, stiff, wing-like appendage covering all but the dorsal surface (text-fig. 16). The dorsal face of the seed-body is obovate in outline and has a median longitudinal groove (raphe-groove ?). In the specimen figured on Pl. XXIII, fig. 1, the cells of the testa covering the dorsal face have been worn away so that the form of the seed-body is well seen. The wing (Pl. XXIII, figs. 1–3) is formed by the cells of the testa, the median groove seen on the seed-body is continued to the apex of the wing. The seed-coats are as follows, passing from within outwards :—

(1) An inner coat (the tegmen ?) formed of a single layer of small square or oblong cells, 0·016 mm. broad, which are aligned in longitudinal rows, but also have a marked tendency to be concentrically aligned around the apex (chalaza ?) of the seed-body.

(2) A coat outside this, which differs in character on the dorsal and ventral faces. It is this coat which forms the large wing-like appendage on the ventral face of the seed. On the dorsal face the cells which form it are large but smaller than those of the ventral face, and are not elongate at right-angles to the surface of

the seed. On the ventral face they are elongate, some cells measuring as much as 0·6 or 0·9 mm. in length, and 0·05 mm. in diameter. Everywhere on the ventral surface the cells are aligned with their longest axes at right-angles to the surface of the seed-body, except that at the margin of the dorsal surface they are slightly recurved ; consequently at the apex of the seed the alignment is upwards (Pl. XXIII, figs. 2, 3). The cells, though very large, are close set and compacted, being hexagonal in cross-section. Sometimes the thickness of the wing is formed by a single cell, sometimes by two or three cells placed end to end (text-fig. 16). Over the whole ventral surface they are so compacted and of such appropriate lengths that the ventri-lateral faces of the thick wing meet at an angle of 90°, exactly fitting the right-angled space between the septa. The cells taper to a point rather suddenly at their free ends. Their lateral surface shows conspicuous oblique markings due to oblique (spiral ?) ridges.

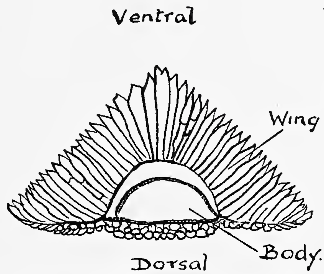


Fig. 16.—Diagrammatic transverse section of seed of *Palaeeucharidium cellulare*.

(3) On the outer surface of the second coat, both over the dorsal and ventral faces, are obscure impressions of small cells on one of the seeds. Whether these represent a third coat, or merely the cells of the locule-lining, we cannot tell. Length of seed, 4 mm. ; breadth of dorsal face, 2·33 mm. ; greatest dorsi-ventral thickness, 1·7 mm. Length of seed-body, 2 mm. ; breadth, 0·6 mm. ; thickness, 0·3 mm.

Remarks.—One specimen found by ourselves at Minster in 1929. It was originally perfect except for the missing pericarp. This may mean that dehiscence took place by the removal of dorsal valves which fell away leaving the seeds attached to the axis, the septa persisting between them, or it may be merely the result of abrasion. Two of the seeds show only the dorsal surface of the cast of the seed-cavity surrounded by the large cells of the wing. The other two seeds show the casts of the seed-cavity partly obscured by the remains of the testa. The longitudinal groove (of the raphe ?) is also clearly seen, and in one seed this groove is continued to the apex of the wing (Pl. XXIII, fig. 3), the large cells diverging obliquely from it as described. We were unable from the superficial characters to discover whether there were any septa present ; that is, whether the fruit were one- or four-loculed. We therefore fractured the specimen longitudinally ; it broke cleanly in half, showing the septa lying between the seeds (Pl. XXIII, fig. 4). A transverse fracture was made across two of the seeds in order to discover whether the large cells formed merely a thin marginal wing or were continued over the ventral surface to form a solid appendage. The fracture proved the latter to be the case. After the specimen was examined further natural disintegration took place.

Affinities.—We first attempted to discover the affinities of this fruit by making a list of all families which contained four-loculed fruits with one seed in each locule, and then studying these families in connexion with our notes and drawings made in Kew Herbarium, but we failed completely to find any genus with seeds at all resembling those of the fossil. We next examined the whole of our seed collection, with the result that we found *Eucharidium* Fisch. & Mey. had seeds of remarkably similar character. The seed-body in this genus is covered by low, rounded tubercles, and is marked off by a groove from the winged periphery, which is formed of exactly comparable large cells, the surfaces of which show oblique markings. The testa on the dorsal side of the seed-body is formed of a single layer of coarse parenchyma. The seed-cavity is lined by small longitudinally arranged cells. The chief differences between the seeds of *Eucharidium* and those of the fossil are as follows :—

(1) The greater size of the latter.

(2) The distribution of the coarse cells of the testa, which arise in the fossil all over the ventral surface but which in *Eucharidium* merely form a marginal fringe.

(3) The single layer of testa cells over the dorsal surface of the body.

(4) In *Eucharidium* the lateral portions of the wings are completely recurved and folded on to the ventral face so that the two margins meet at the middle of the ventral face. In the fossil the lateral portions of the wings are expanded and fill the angles between the septa; only those cells at the margin are slightly recurved.

(4) The fruits of *Eucharidium* are two-loculed and contain numerous seeds in each locule.

Although the fossil cannot therefore be very closely allied to *Eucharidium*, nevertheless in view of the structural similarities which exist between the seeds in the two cases, and in view also of the fact that the Onagraceae, to which *Eucharidium* belongs, is one of the few families in which four-loculed fruits with solitary seeds in the locules occur, we are obliged to refer the fossil to the Onagraceae and have given it the name *Palaeeucharidium* to mark its distinctive character.

V. 22895 Holotype, figured Pl. XXIII, figs. 1–4. A fruit with the carpel walls dehisced or abraded. The specimen is now fractured longitudinally, and one half is also fractured transversely. *Reid & Chandler Coll.*, Minster, 1929.

Family NYSSACEAE

Endocarps belonging to certain members of the family Nyssaceae have a number of distinctive characters :—

(1) They are rather large and of a regular ovoid form.

(2) They are longitudinally ribbed and furrowed with, or without, bands of fibres lying in the furrows. The ribs (which may be very elaborately sculptured) are strictly longitudinal, except that in the genus *Nyssa* and in some allied fossil genera, the two ribs flanking the valves of dehiscence deviate from this alignment in conformity with the curvature of the valves (cf. Pl. XXIII, fig. 5; Pl. XXIII, fig. 11).

(3) The endocarps are very hard and woody, formed in *Nyssa* of highly contorted bundles of fibres interspersed with woody parenchyma.

(4) Germination takes place by the removal of sub-triangular valves from the

upper part of the dorsal wall of the endocarp ; the valves covering the expanded hilar end of the seeds (cf. Pl. XXIII, figs. 5, 7 ; Pl. XXIII, figs. 11, 12).

(5) The seed is straight, expanded above and narrowed below, anatropous, with ventral raphe.

(6) The tegmen cells are accurately aligned in transverse rows.

These characters taken together serve completely to distinguish many of the Nyssaceae. The other family with species which are comparable in these respects, and with which confusion is most likely to occur, is the Cornaceae. In this family certain genera show very similar large, ovoid, ribbed endocarps which dehisce by throwing off dorsal valves (*Mastixia*, *Cornus*), and have the tegmen cells accurately aligned in transverse rows (*Mastixia*). But they may usually be distinguished by the form of the germination valve, which in the Cornaceae extends the full length of the locule, and by the undeviating regularity of the longitudinal ribs. It is fortunate that the processes of fossilization usually display the form of germination valves with great clearness in fossil endocarps ; much more clearly than in living endocarps, unless these have germinated.

The Nyssaceae are certainly represented in the London Clay by two genera, and possibly by three or four. The two genera, *Protonyssa* and *Palaeonyssa*, which can definitely be referred to the family both possess a greater number of locules than is found in the genus *Nyssa*, which they most resemble ; they have fewer locules than occur in *Davidia*, which also belongs to the family. We have found evidence from the London Clay in the present work (Mastixiodeae, p. 447), and from the study of the Bembridge flora (*Sparganium*, Reid & Chandler, 1926, p. 63, pl. iii, figs. 13–17), to show that living genera with one (or at most two) locules may be represented in the past by multilocular genera, indicating that evolution has resulted in suppression of locules.

Genus PROTONYSSA nov.

DIAGNOSIS.—Endocarp two-loculed, with one seed in each locule ; the other characters both of fruit and seed resemble those of *Nyssa*.

GENOTYPE.—*P. bilocularis* n. sp.

Protonyssa bilocularis n. sp.

PLATE XXIII, figs. 5–10.

1879. *Symplocos radobojana* Ettingshausen, p. 394.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22896.

DESCRIPTION.—*Endocarp:* Ovoid, syncarpous, two-loculed, with one seed in each locule, germinating by the removal of a large sub-triangular valve, which is broad at the base, from the upper end of the dorsal face of each carpel (Pl. XXIII, fig. 7). A smooth external skin, preserved in a few places, may perhaps represent the epicarp, the cells of which cannot be distinguished. Endocarp wall thick, woody, fibrous. Externally its parenchymatous cells are aligned so as to give a transversely striate surface. Embedded in this parenchyma there are about eight or ten longitudinal bands of fibres which run from base to apex. Two of these bands follow the margins of the valves, diverging slightly outwards in conformity with their curvature (Pl. XXIII, fig. 5). In section the endocarp is formed of a mass of tortuous, intertwined, woody fibres with a general radial arrangement, especially towards the periphery; within these is a series of flat layers of fibres which form the bulk of the endocarp wall; the innermost layer of these fibres being transversely aligned, the locule appears transversely striate, but when the impressions of the overlying layers is preserved there is a criss-cross effect. Length of endocarp, 18·5 mm.; diameter, 10 mm.; length of valve, 8 mm.

Seed: Pendulous, conforming in shape to the locule, compressed dorsi-ventrally, spathulate (Pl. XXIII, figs. 9, 10), less markedly lunate in section than the seeds of *Palaeonyssa multilocularis* (p. 432); anatropous, with broad, median, ventral raphe, and terminal chalaza at the narrow end of the seed, micropyle terminal at the broad end of the seed. Testa formed of more or less rectangular cells elongated and aligned longitudinally so as to produce longitudinal striations about 0·025 to 0·033 mm. apart. Tegmen formed of rectangular or faceted cells aligned accurately in transverse rows about 0·016 mm. apart. Length of ripe seed, 17 mm.; greatest breadth, 6 mm.

Remarks.—Three fruits belonging to the Bowerbank Collection. The most perfect (V. 22896) was obviously disintegrating, and was photographed prior to study (Pl. XXIII, fig. 5). Afterwards it fell to pieces, thereby exposing the perfect locule-casts enclosing the casts of the seeds (Pl. XXIII, fig. 6). The specimen shows very clearly the form of the germination valves and the mode of dehiscence (Pl. XXIII, fig. 7), for, as commonly occurs in fossil fruits, disintegration has followed the planes of weakness bounding the edges of the valves. Another small but perfect fruit, with outlines of the germination valves and the characteristic longitudinal fibre bands on the external surface of the endocarp, was fractured transversely and then showed clearly the position and form of the two locules. In the third specimen the endocarp is preserved over the upper half of the nut only. At the base it is worn away, so that the two locule-casts protrude for half their length (Pl. XXIII, fig. 8), and at the extreme base even these have been so much abraded that the chalazal ends of the two seed-casts, lying within them, are exposed.

Affinities.—In the structure of the carpel wall, the mode of dehiscence, the form and position of the germination valve, the structure of testa and tegmen, the form of the seed, and the position of the raphe and chalaza, the fossils differ in no respect from the living *Nyssa*. The only distinction we have been able to discover between the living genus and this fossil species is the difference in the number of locules; the fossil is a syncarpous fruit with two locules, whereas *Nyssa* never has more than one locule. It is highly probable, therefore, that the fossil is a primitive form of *Nyssa* and that the living genus has been derived from this, or a related ancestor, by the suppression of one locule (cf. p. 42).

Nyssa is a genus found in North America, Himalaya, China, and Malaya. It has constantly been recorded fossil in beds of Tertiary age, and is included in

Ettingshausen's list of Sheppey fruits under the name *Nyssa eocenica* (1879, p. 394). The specimen so named had disappeared before we began the study of the London Clay fruits, hence we cannot ascertain whether or not it were a true *Nyssa*, a specimen of *Protonyssa bilocularis*, or some other allied genus. It is possible that the determination was completely erroneous, for we know that the holotype of *P. bilocularis* (V. 22896) was labelled by Ettingshausen "*Symplocos sagoriana*," and listed by him as *Symplocos radobojana* (1879, p. 394).

Nyssa fruits of possible Eocene age are recorded from the Brandon Lignites of Vermont, U.S.A., where the genus appears to have been peculiarly abundant, although the species have almost certainly been unnecessarily multiplied. Some of the species described and figured as *Nyssa* can be accepted without hesitation as correctly determined (Perkins, 1904, pl. lxxix, figs. 93, 94, 96–98, 100, 103), but although well illustrated, they are very inadequately described. It is also probable from the figures that some true Nyssas were referred to other genera (cf. *Glossocarpellites*, Perkins, 1904, pl. lxxv, figs. 1–20; 1905, pl. lxxxvi, figs. 1–3). The age of the Brandon Lignites has never been satisfactorily determined; various opinions are mentioned on pp. 87, 88.

Two particularly beautiful silicified specimens have been described as *Nyssa oviformis* by E. M. Reid from the Eocene Quartzites of Saint Tudy, Finistère (1930, p. 45, pl. i, figs. 4–6); every cell and fibre is perfectly reproduced, and the seeds within are also preserved. The germination valves are very clearly seen.

Endocarps were described as *Nyssa texana* by Professor E. W. Berry (1924, p. 88, pl. xxii, fig. 5), and by Professor O. M. Ball (1931, p. 129, pl. xx, fig. 12) from the Middle Eocene of Texas. The illustrations suggest that the ascription is right, but the generic identity is not conclusively established by observation of the characteristic germination valve or cell-structure.

V. 22896 Holotype, figured Pl. XXIII, figs. 5–7, 9, 10. An endocarp, now fallen to pieces so as to show the locules and a cast of one of the seeds. The specimen was labelled "*Symplocos sagoriana*" by Ettingshausen; it is probably the same as that listed by him under the name *Symplocos radobojana* (1879, p. 394).

V. 22897 Figured Pl. XXIII, fig. 8. An abraded endocarp with the casts of the two locules protruding beyond the adherent remains of the carpel wall, especially at the base.

V. 22898 A small but perfect endocarp, fractured transversely to show the two locules.

All are from the Bowerbank Coll., Sheppey.

Genus PALAEONYSSA nov.

DIAGNOSIS.—Endocarp three- to four-loculed, with one seed in each locule. The other characters resemble those of *Nyssa*, except that the germination valves are narrowed at the base, not broad as in that genus.

GENOTYPE.—*P. multilocularis* n. sp.

Palaeonyssa multilocularis n. sp.

PLATE XXIII, figs. 11–15.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 22899.

Description.—*Endocarp:* Ovoid, syncarpous, three- or four-loculed, the locules reniform in section, the concave side being directed outwards; each locule one-seeded, dehiscing by an oval valve which is rather less than half the length of the endocarp and is situated near the apex (Pl. XXIII, figs. 11, 12). In one specimen the valve is more attenuated towards the base than in any of the others. Endocarp wall thick, woody, and fibrous, formed of two coats; the outer consists of coarse, tortuous, intertwined fibres with a general radial direction; many of the fibres become transversely aligned at the periphery so that the outer surface of the endocarp appears transversely striate or rugose. In transverse section this woody coat forms massive columns between the locules. The columns on the external surface of the endocarp form broad gently rounded ribs, double in number to that of the locules. As they reach the level of the valves the ribs narrow conspicuously on the side adjacent to the valves so as to curve around them and outline their margins. There are no longitudinal superficial bands of fibres in this species such as are so conspicuous on the surface of the endocarps of *Protonyssa bilocularis* (p. 429).

The inner coat of the endocarp is thick and woody, formed of several overlying flat layers of fibres. In the innermost layer the fibres are aligned transversely so that the locule is transversely striate. Frequently the superposition of these variously aligned layers produces a criss-cross effect. Length of endocarp, 15 mm.; diameter, 9·5 mm.

Seed: Pendulous, anatropous, conforming in shape to the locule, compressed dorsi-ventrally, ovate-lanceolate in outline, sub-lunate in section in the lower part, the convex surface being ventral, that is, turned towards the axis of the endocarp, the concave surface dorsal, that is, turned towards its periphery; raphe median on the ventral face, thick, flat, and conspicuous, chalaza terminal at the narrow end of the seed; testa thin, with external longitudinal striations about 0·016 mm. apart; tegmen formed of small, square, or oblong cells, accurately aligned in transverse rows, resulting in transverse striations about 0·025 mm. apart.

Remarks.—Four specimens belonging to the Bowerbank Collection. One specimen, abraded at the base so that its three seeds project slightly beyond the endocarp, shows very clearly the outlines of the valves on the surface; it was fractured longitudinally so as to expose the seed with its ventral raphe (Pl. XXIII, figs. 11–14). Another specimen (Pl. XXIII, fig. 15) which was perfect, was fractured longitudinally and transversely and was thereby proved to have four locules. The third specimen is abraded at base and apex. The fourth specimen is fractured longitudinally; it shows the germination valves. The identity of external morphology, internal morphology, and cell-structure, in the three- and four-loculed specimens, shows that they must be referred to the same species.

Affinities.—The macroscopic and microscopic characters of both endocarp and seed and the highly characteristic mode of germination make it certain that the nuts described belong to the family Nyssaceae and are closely allied to *Nyssa*. But between the living genus *Nyssa* and the fossils there are fundamental distinctions. In the first place *Nyssa* is one-loculed, whereas the fossil is three- or four-loculed. Again the germination valves are of a somewhat different shape from those of all living species of *Nyssa*, in which they are roundly triangular with a wide base, which, however, is not clearly delimited, like the rest of the margin, but breaks irregularly. In the fossil species the valve is oval and narrowed to the base. The same distinctions differentiate it from *Protonyssa bilocularis*, from which it is also distinguished by its rounded ribs and by the absence of the flat longitudinal strands of fibres, so conspicuous in that species. The distinctive character of the valves probably points to a generic difference. The number of locules is of much less importance and might merely indicate a more primitive type both of the living and fossil genera (cf. p. 42).

V. 22899 Holotype, figured Pl. XXIII, figs. 11–14. An endocarp, showing the three germination valves, abraded at the base so that the three seeds project beyond it. The seeds have been exposed by fracturing the endocarp longitudinally; the ventral raphe is visible.

V. 22900 Figured Pl. XXIII, fig. 15. An endocarp, less abraded than the holotype, so that the outlines of the valves are obscure. The specimen, which was fractured longitudinally and transversely, has four locules.

V. 22901 An endocarp, abraded at base and apex, fractured transversely.

V. 22902 An abraded endocarp showing the germination valve; fractured longitudinally.

All are from the Bowerbank Coll., Sheppey.

Palaeonyssa sp.

Plate XXIII, figs. 16, 17.

Description.—*Endocarp:* Obovoid, with irregular, large, longitudinal ribs; syncarpous, four-loculed, the locules being sub-triangular in section with the dorsal side concave. Locules one-seeded, dehiscing by an oval valve which is less than half the length of the endocarp and is situated near the apex. Endocarp wall thick, woody, and fibrous, the fibres, which are finer than in *Palaeonyssa multilocularis*, being tortuous and intertwined, with a general radial direction. There are no external longitudinal strands of fibres. The inner coat of the endocarp is formed of a few (two or three ?) flat layers of fibres which are aligned in different directions, thus producing a criss-cross effect, the innermost layer being aligned transversely. Length of endocarp, 12 mm.; diameter, 11 mm. Length of germination valve, 5 mm.; breadth, 3 mm.

Seed: Conforming in shape to the locule, concave on the dorsal and convex on the ventral side. Testa (seen for the most part in section only) longitudinally striate; tegmen not seen.

Remarks.—One much battered specimen; it appears to be distorted so that the ribs do not stand out clearly, nor are the valves easy to detect. When fractured the specimen broke obliquely, so that it was difficult to trace the various locules and valves in section. One of the latter appears to have fallen away, one can be seen relatively easily, the remaining two are obscure.

Affinities.—There can be no doubt from the structure of the carpel wall and of the endocarp generally that this specimen belongs to *Palaeonyssa*. Whether it should be referred to *P. multilocularis* is more doubtful. Undoubtedly the fibres are finer and the locules differ in section, those of *P. multilocularis* being reniform with the concave side dorsal, those of the specimen under discussion being subtriangular with a slightly concave dorsal side. Moreover, the ribbing in this specimen is more conspicuous than in *P. multilocularis*, while the fruit appears to be narrower at the base and obovoid instead of ovoid, but it is possible that these differences may be the result of under-development and distortion. In any case the specimen is too much worn and, in consequence, its form is too indefinite for it to be worth a specific name.

V. 22903 Figured Pl. XXIII, figs. 16, 17. An endocarp, now broken into several fragments. *Bowerbank Coll.*, Sheppey.

Family NYSSACEAE ? (or Cornaceae ?)

Genus ? sp. 1

Plate XXIII, figs. 18, 19.

Description.—*Endocarp:* Ovoid; a two-loculed drupe; probably germinating by throwing off long dorsal valves which reach nearly the full length of the locules, because the dorsal faces of the locule-casts are exposed for most of their length, and because the clearly defined, slightly ribbed, lateral margins of the locule-casts (Pl. XXIII, fig. 18) suggest that valves have fallen away, although the carpel wall is now so worn between the locules that no remains can be traced of finished surfaces, such as are associated with the presence of valves. Carpel wall (as preserved between the locules) formed of a thick mass of fibres which lie parallel to the subparallel ventral faces of the locules, but in the angular spaces between their lateral walls and the periphery of the nut, form massive blocks of tortuous strands of fibres interspersed with parenchyma. One only of these blocks of fibres is preserved intact, the other is largely abraded. Externally the surface of the intact fibrous mass, which is the only part of the periphery of the fruit now preserved, shows a few filiform ridges on which run slender longitudinal strands of fibres. Locule-lining formed of longitudinally aligned cells so that the locules are longitudinally striate. Both locules extend the complete length of the fruit, as preserved; indeed, at one end, the locule-casts protrude, the surrounding carpel wall having been worn away. Both locules are longitudinally angled on the peripheral side, so that there are two dorsal facets, the angular ridge between them having a slight spiral twist, so that one facet is larger at one end, and the other at the opposite end. The locules are more or less quadrilateral in section (Pl. XXIII, fig. 19).

The endocarp is too worn to permit of its original dimensions being determined. As preserved it measures: Length (imperfect), 11 mm.; diameter (imperfect), 8 mm.

Seed: Solitary in the locule, to which it corresponds in shape. The seed (or seed-cast) is seen only in one minute patch; only one coat is visible (probably the tegmen), formed of small cells, transversely aligned.

Remarks.—One specimen, found by ourselves at Minster in 1929. On being transversely fractured (Pl. XXIII, fig. 19), it showed the structures described. The whole specimen is strongly impregnated with pyrites, so that it broke irregularly, thereby exposing in one minute patch the surface of the seed or seed-cast.

Affinities.—The longitudinally ridged, woody, two-loculed fruits with the probable indications of valvular dehiscence, the character of the fibrous endocarp and of the locule-lining, all suggest relationship with Nyssaceae or Cornaceae, a relationship supported by the character of the only seed-coat seen, which corresponds closely with the tegmen of *Nyssa* or *Mastixia*. The locules resemble those of *Davidia* (Nyssaceae) in shape, while the valves, like those of *Davidia* or *Alangium*, are longer than those of *Nyssa*; they may be as long as the valves of certain Cornaceae, but the abraded condition of the only specimen known makes their precise extent uncertain. There is not sufficient evidence, except for the general resemblances described above, to associate the fossil with any particular living genus, but it differs in the shape of its locules from either of the extinct genera of Nyssaceae already described from the London Clay. Thus whilst it almost certainly represents a separate species, and in all probability a separate genus, the fruit is too imperfect, especially as regards its form and the manner of its dehiscence, for complete and adequate description. We have, therefore, refrained from referring it to a genus or species and have referred it only doubtfully to a family.

V. 22904 Figured Pl. XXIII, figs. 18, 19. An endocarp, fractured transversely to show the two locules. *Reid & Chandler Coll.*, Minster, 1929.

Genus ? sp. 2 (NYSSACEAE or CORNACEAE ?)

Plate XXIII, fig. 20.

Description.—*Seed:* Ovate in outline, flattened triangular in section, with an obtuse median longitudinal ridge on one face; anatropous or orthotropous, but probably the former, as the ridge may mark the position of the raphe, with hilum and chalaza at opposite extremities. The internal cast of the testa, which is alone preserved, shows the impression of square or oblong cells aligned accurately in transverse rows. Length of seed, 4·5 mm.; breadth, 3 mm.; thickness, 1·1 mm.

Remarks.—One specimen, found by ourselves at Minster in 1929. It is the internal cast of a seed, and was originally partly covered by a film of structureless pyrites which must have formed the infilling between the inner and outer coats of the testa or between the testa and the locule-lining. At one end the cells could be seen arranged transversely in concentric rings. Subsequently we chipped off the pyrites film from much of the surface, thereby exposing the other end of the seed.

Affinities.—The character and arrangement of the cells covering the surface of the specimen strongly suggest affinity with Nyssaceae or Cornaceae (*Mastixia*), the only two families in which we have observed them so definitely. However, in shape the seed is unlike that of any member of these families known to us. In *Mastixia* the seed has a deep dorsal longitudinal groove in conformity with the longitudinal infold of the endocarp. In *Nyssa* the seeds are flattened and expanded at the hilar end, but narrowed and longitudinally grooved at the chalazal end. In *Davidia* the seeds are long, and usually longitudinally grooved or folded. The extinct fossil species do not afford any further clue as to relationship. We cannot therefore feel certain that the specimen belongs to either family.

V. 22905 Figured Pl. XXIII, fig. 20. An internal cast of a seed. *Reid & Chandler Coll.*, Minster, 1929.

Family MYRTACEAE

Genus PALAEORHODOMYRTUS nov.

DIAGNOSIS.—Fruit a syncarpous, five-loculed, many-seeded, loculicidal capsule, with axile placentation, the seeds being irregularly arranged. Length, 12·5 mm.; diameter, 15 mm. Seed semicircular or gibbous in outline, laterally compressed; embryo U-shaped; testa formed of large inflated cells, prismatic on the dorsal margin, where they may measure 0·7 mm. long and 0·3 mm. in diameter, giving rise to radial ornamentation on the flat faces. Diameter of flat face, 3 mm.

GENOTYPE.—*Cupressinites subangulatus* Bowerbank.

Palaeorhodomyrtus subangulata (Bowerbank)

PLATE XXIII, figs. 21–31.

1840. *Cupressinites subangulatus* Bowerbank, p. 60, pl. x, figs. 24, 25.
1845. *Cupressites subangulatus* (Bowerbank) Unger, p. 193.
1847. *Solenostrobus subangulatus* (Bowerbank) Endlicher, p. 8.
1850. *Solenostrobus subangulatus* (Bowerbank): Unger, p. 343.
1879. *Solenostrobus subangulatus* (Bowerbank): Ettingshausen, p. 392.
1883. *Callitris curta* (Bowerbank) pars: Gardner, pp. 21, 22, pl. ix, figs. 13–21.
1919. *Callitrites curta* (Bowerbank): Seward (pars), p. 340, fig. 761*a*.

DIAGNOSIS.—That of the genus.

NEOTYPE.—V. 22906.

DESCRIPTION.—*Fruit:* Stipitate, sub-globular or roundly pentangular, inferior (?), with accrescent calyx (?), syncarpous, five-loculed, many-seeded, capsular, dehiscing loculicidally at the top only, the carpels splitting for about one-third of their length (Pl. XXIII, figs. 24–26). Fruit wall thick (leathery ?), external surface showing five divisions corresponding to the five valves of the capsule. Each valve is rounded at the apex, perhaps by abrasion, for in one specimen (Pl. XXIII, fig. 26) the apices of the valves are more or less pointed. Surface of fruit formed of equiaxial cells, which were probably somewhat inflated originally, giving a shagreen-like or tessellated appearance. Within the epicarp there is a thick coat of coarse parenchyma, with conspicuous longitudinal strands of fibres, which are best developed at the edges of the valves, where dehiscence occurs. As the result of fossilization this coat readily scales away from the next underlying it, thereby exposing a smooth, longitudinally striate surface formed of elongate cells aligned longitudinally; the cells have thickened walls, but the nature of the thickening is obscure. There are many layers of them, and the coat which they form shows a marked tendency to split into layers. Within it is a thin coat, columnar in section, with embedded longitudinal strands of fibres; it is continuous with the septa, which are also columnar in section. The innermost coat of the pericarp is thin, formed of a few layers of elongate cells (or fibres ?) variously aligned so as to give the locule-lining a tortuous appearance. A thick fibrous axis occupies the middle of the fruit and is associated with the placentas (Pl. XXIII, fig. 31). The seeds lie in various planes, but each has its ventral margin turned to the axis. Length of the most perfect fruit, 12·5 mm.; diameter, 15 mm.

Seed: Semicircular or gibbous in outline, laterally compressed, wedge-shaped in section, the dorsal face being broad, and faceted on to the lateral faces. Testa very thick, especially over the dorsal face, thinning gradually towards the middle of each face, formed of very large cells, particularly on the dorsal face where they are prismatic or bolster-shaped and aligned more or less at right-angles to the surface (Pl. XXIII, figs. 27, 28); one, two, or three cells may occur in the thickness of the testa, some of the largest measuring 0·7 mm. × 0·2 to 0·3 mm. The cell-walls are thin and usually decayed, so that the pyrites casts of the cavities alone remain. Similar, but smaller cells form the testa over the lateral faces; they diminish in size towards the middle of the faces. On the dorsal face the testa-cells form nodulations; on the lateral faces, radial ornamentation (Pl. XXIII, fig. 29). On the lateral faces, on the outer surface of the coat just described, there is a delicate network of large, elongate, hexagonal or polygonal cells, which indicates either the presence of a thin skin formed by smaller cells, or that the abnormally large cells of the testa are formed by the fusion of more than one cell (Pl. XXIII, fig. 29). Tegmen formed of delicate polygonal or quadrangular cells, about 0·025 to 0·033 mm. in diameter (Pl. XXIII, figs. 30, 31). Embryo U-shaped (Pl. XXIII, figs. 30, 31), the limbs being occasionally equal, but, more usually, unequal; they are also sometimes twisted so as not to lie in the same plane. The space between the limbs is occupied by the raphe and the cells which surround it, and over this space the testa passes without interruption. Hence the difference in form between the seed and embryo. Immediately over the raphe the cells of the testa are aligned parallel to it and to the limbs of the embryo. Chalaza and micropyle at the ends of the two limbs; the chalaza is a marked circular scar, situated slightly excentrically at the rounded end and towards the inner face of the shorter, broader limb; the micropyle, a less conspicuous scar at the end of the longer, thinner limb (Pl. XXIII, fig. 30). Diameter of perfect seed, 3 mm.; width across dorsal face, 1 to 2 mm.; greatest width across limbs of embryo, 1·5 mm.

Affinities.—Seven specimens. There can be no hesitation in assigning these fruits to the family Myrtaceae, where similar inferior, stipitate, multilocular fruits with adherent calices occur. Seeds with curved U-shaped embryos having unequal limbs twisted out of a single plane are found in the section Myrtinae (Niedenzu); and among the plurilocular genera in this section, so far as we have been able to examine their seeds, *Rhodomyrtus* Reichb. alone has the testa formed of very large cells graded in size from the dorsal margin to the centres of the lateral faces, as in the fossil. In this genus, also, the raphe and associated cells occupy the space between the two limbs, and the testa cells in that part of the seed are aligned parallel to the raphe. There are, however, essential differences between this genus and the fossil. In *Rhodomyrtus* the seeds are horizontally arranged, and are piled in vertical rows in each locule, whereas in the fossil they lie in various planes. In *Rhodomyrtus* again, the seeds are much more flattened and the lateral surfaces show a series of concentric striations not seen in the fossil, although, as described above, there is evidence of a delicate network of cells over the surface. While, therefore, the fossil must be regarded as allied to *Rhodomyrtus*, it cannot actually be placed in the genus.

Rhodomyrtus is a native of eastern Asia, from Japan to the Malay Islands, and of Australia.

Although Bowerbank's type of *Cupressinites subangulatus* appears to be no longer extant, there can be no doubt from Sowerby's figures that it was a specimen of the fruit described above. Bowerbank's diagnosis, which is not very illuminating, is as follows: "*Cupula* five-cleft: exterior surfaces of the segments subangular." No details of cell-structure are given in his description, and he does not mention any seeds, presumably because they had either fallen from the fruit, or had become embedded in an incrustation or infilling of pyrites by which they were completely hidden, both of which conditions are represented among the material examined by us.

Among the specimens which Gardner figured and described (1883, p. 21, pl. ix, figs. 7–21), under the name of *Callitris curta* (Bow.), are some, figs. 13–21, which clearly belong to *Palaeorhodomyrtus* (including the type of *Cupressinites subangulatus* Bowerb.), whereas others, figs. 7–12, have different affinities, discussed elsewhere (pp. 96, 145, 459). Of those specimens which suggest identity with *Palaeorhodomyrtus*, one, the original of Gardner's fig. 21, is still extant. This fruit shows the highly characteristic seed, so that its identity with *Palaeorhodomyrtus* is satisfactorily established. The characters of fruit and seed are such that any ascription to Cupressineae is out of the question, and Bowerbank's name *Cupressinites* must be retained for fruits which really have that affinity (p. 96).

The genus *Rhodomyrtus* has been doubtfully recorded by E. M. Reid (1930, p. 48, pl. i, figs. 9, 10) in material from St. Tudy, Finistère. The age of the St. Tudy deposit is not definitely known, but the available evidence is thought to point to an Eocene age, and this is supported by the character of the small flora. Only separate seeds of *Rhodomyrtus* were obtained and they are in such a crumbling condition that the characteristic coarse cells of the dorsal side of the testa cannot be photographed, although they can be observed. The internal casts of the seeds showing the unequal, slightly twisted, U-shaped limbs are well-preserved; the limbs are more slender than those of the London Clay species. Whether the St. Tudy seeds belong to the living genus *Rhodomyrtus*, or whether they may not rather belong to an extinct genus such as *Palaeorhodomyrtus*, cannot be determined in the absence of fruits.

In 1931 Dr. Helena Bandulska described the leaf and cuticle of *Rhodomyrtus sinuata* (Bandulska) from the Bournemouth Beds (1931, p. 659, pl. xxxix, figs. 1, 2, 4, 5, 8; text-figs. 8–11).

V. 22906 Figured Pl. XXIII, figs. 21–23, 27–31. An imperfect fruit, much abraded externally, with three carpels preserved. The specimen is broken so as to show the seeds lying in the locules. The coarse cells of the testa are clearly seen. The external surface of a seed is impressed on a film of pyrites which originally lay between the seed and the septum.

V. 22906*a* The internal cast of a seed from the same fruit. It shows the tegmen, micropyle, and chalaza (figured Pl. XXIII, fig. 30). *Bowerbank Coll.*, Sheppey.

V. 22907 Figured Pl. XXIII, fig. 26. A fruit, in which dehiscence has begun, with the peduncle. Also figured by Gardner under the name *Callitris curta* (1883, pl. ix, fig. 21). *J. S. Gardner Coll.*, Sheppey.

V. 22908 Figured Pl. XXIII, figs. 24, 25. A fruit, somewhat abraded, showing the loculicidal dehiscence. *Bowerbank Coll.*, Sheppey.

V. 22909 Three fruits, one fractured longitudinally; two show traces of seeds. *Bowerbank Coll.*, Sheppey.

V. 22910 A fruit, much encrusted with pyrites, fractured longitudinally. The carbonaceous coats of the seeds were preserved when the specimen was first fractured. *Bowerbank Coll.*, Sheppey.

V. 22907–08, and two of the fruits numbered V. 22909, were in a box with the following label written by Mr. W. N. Edwards :—

" *Callitrites curta* (Bow.), London Clay, Sheppey ? Bowerbank Collection."

On the reverse of the label was the following note :—

" Several specimens of *Callitrites* have completely decayed away, and in some cases the labels and numbers have also been destroyed by pyritization.

" Only one of the specimens figured by Gardner has been identified and none of the Bowerbank specimens. W.N.E. Aug. 4, 1921."

Family MYRTACEAE ?

Genus HIGHTEA Bowerbank emend.

1840. Fossil Fruits and Seeds of London Clay, p. 25.

Diagnosis.—Fruit globular or ovoid, syncarpous, five- (rarely four- or six-) carpelled, one-loculed, with placentas at each of the angles of an obconical columella, the number of angles corresponding to the number of carpels ; seeds four, or fewer, at each angle, two erect and two pendulous. Seed elongate, flattened dorsally at the hilar end, and terete at the chalazal end, anatropous, with hilum and chalaza terminal.

Genotype.—*H. elliptica* Bowerbank.

Discussion.—The earliest record of the fruit afterwards designated *Hightea* by Bowerbank occurs in Parsons' account of "Some Fossil Fruits and other Bodies, found in the Island of Shepey" (1757, p. 396). In fig. 1, pl. xvi, he illustrates an unmistakable columella of *Hightea*, the descriptive remark regarding this figure being, " if this be an euonymus it is not so far advanced as to form seeds."

About half a century later James Sowerby (1809, pl. 300) figured several other specimens of the genus. The figures in his plate are unnumbered, but the following represent *Hightea* : top row, middle figure—a fruit, exterior ; second row, left-hand figure—a fruit (possibly) ; third row, left-hand figure—a fruit, exterior; middle figure—a detached columella ; right-hand figure—a fruit broken to show the columella.

The following illustrations in Crow's manuscript catalogue also represent *Hightea* : 102, a columella, and a columella lying in a fruit ; 314, a columella lying in a fruit ; 496 ?, and 564—fruits.

In 1840 Bowerbank named the fruits *Hightea* in honour of a friend and botanist, John Hight. He made an admirable detailed study of the structures of both fruits and seeds, but acknowledged that it was difficult to say with any certainty to which of the natural orders the fossils belonged. He suggested the Malvaceae as affording the most probable relationship, but it is worth noting that Brongniart (1849, p. 84) did not accept this relationship. For a discussion of the differences between our interpretation of the fruit and Bowerbank's, necessitating an amended diagnosis, see p. 443.

Bowerbank divided the fossils belonging to this genus into ten species. His diagnoses show that his classification depends upon small variations in shape, such as are individual rather than specific, and afford entirely inadequate grounds for a multiplication of species. Confirmation of this view is found on turning to the specimens themselves, when such differences are seen to be connected with the relative degree of development of the endocarp or seeds. The only differences of specific value are those which occur between *Hightea turgida* Bowerbank and the remaining nine oval forms which are variously named by him as separate species. These nine species are merely based on individual variations and are not worthy even of varietal distinction. *H. oviformis*, according to Bowerbank, is the most abundant type, and it represents the average form of the species. We have retained *H. turgida* as a distinct species, and united the other nine under the name *H. elliptica*, as this is the first species described by Bowerbank, and one of his figured specimens survives.

Hightea sp. is listed from Clapham by Mr. A. G. Davis, without any comment (1928, p. 351).

Hightea elliptica Bowerbank

PLATE XXIV, figs. 1–17.

1840. *Hightea elliptica* Bowerbank, p. 32, pl. viii, figs. 7–9.
1840. *Hightea elegans* Bowerbank, p. 32, pl. viii, figs. 10, 11.
1840. *Hightea attenuata* Bowerbank, p. 33, pl. viii, figs. 12–17.
1840. *Hightea fusiformis* Bowerbank, p. 34, pl. viii, figs. 18–21.
1840. *Hightea inflata* Bowerbank, p. 35, pl. viii, figs. 22, 23.
1840. *Hightea oviformis* Bowerbank, p. 36, pl. viii, figs. 24–26, 28.
1840. *Hightea turbinata* Bowerbank, p. 38, pl. viii, figs. 29, 30.
1840. *Hightea orbicularis* Bowerbank, p. 38, pl. viii, figs. 31–33.
1840. *Hightea minima* Bowerbank, p. 39, pl. viii, figs. 34–36.
1879. *Hightea elliptica* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea elegans* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea inflata* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea oviformis* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea turbinata* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea orbicularis* Bowerbank: Ettingshausen, p. 395.
1879. *Hightea minima* Bowerbank: Ettingshausen, p. 395.
1879. *? Livistona eocenica* Ettingshausen (pars), p. 393.

DIAGNOSIS.—Fruit sub-globular or ovoid; sides of columella usually convex (occasionally slightly concave) narrowing gradually into the stalk; typical pendulous seed length, 8·5 mm.; breadth, 2·5 mm.; typical erect seed length, 5 mm.; breadth, 2·5 mm.

HOLOTYPE.—V. 22925.

DESCRIPTION.—*Fruit:* Sub-globular or ovoid, with a small, slightly swollen stalk, which may come away leaving a deep hollow; syncarpous, formed normally of five carpels, but very rarely of four or six; dehiscing by gaping at the apex above the top of the swollen columella, but not below (Pl. XXIV, fig. 4), along planes running to the placental angles; one-loculed, the seeds being embedded in pockets. The large columella is quite free from the pericarp; it is an angular, obconical body, often stipitate or sub-stipitate with a more or less flattened apex and as many angles as there are carpels (Pl. XXIV, figs. 6–9). Its form varies within certain limits; in some specimens the angles are sharp and the sides concave, in others they are blunt and the sides convex. Again, it may be very swollen, or almost slender. The apex may be flat, but is sometimes slightly convex. From the centre of the flattened top to each angle a deep groove runs (Pl. XXIV, fig. 6) dividing the angle so as to form a pair of small knobs which are the actual placentas: to each placenta one or two seeds may be attached. When there are two, one is erect and lies on top of the columella and one pendulous, lying along its lower surface. Consequently at each angle of the columella four seeds may be attached, although usually there are fewer. The stem of the columella has a core of fibro-vascular bundles which arise from the stalk and are embedded in a mass of coarse, occasionally angular, parenchyma, the cells of which vary from 0·075 to 0·1 mm. in diameter (Pl. XXIV, figs. 7, 9). Each bundle of fibres bifurcates a little above the middle of the columella, one strand passing into one of the placental angles, where it forms the two placentae, as described, the other continuing to the apex of the columella, where it passes out through a small canal (situate in the angle between two grooves (Pl. XXIV, figs. 5, 9)). The outer surface of the columella is closely invested by an integument formed of a few layers of transversely aligned fibres. This integument is identical with that lining the seed-pockets and with that which forms the innermost layer of the pericarp. It must therefore constitute the locule-lining; and its complete envelopment of the columella, including the surface which underlies the seeds, as well as its continuance over the whole inner surface of the pericarp, must indicate that the fruit is one-loculed.

Passing from the exterior of the fruit to the interior we have observed the following carpellary coats: (1) An external coat formed of large prismatic cells with their long axes directed radially. This coat is figured by Bowerbank as the pericarp. It is followed by (2) a coat of fine parenchyma several cells thick, the cells aligned radially. Between these two coats, or sometimes partly embedded in the one or the other, are ten longitudinal bands of fibres which run from base to apex, one opposite each angle of the columella and one median between the angles. (3) Next comes a coat varying greatly in thickness, and formed throughout of fibres. The outer part of this coat is formed of coarse fibres. Above the top of the columella, and over its constricted sides below, these are highly contorted and aggregated into thick masses which, above the columella, form a conical cap, and, below, fill up the concavities between the lobes of the columella, so that the fruit is globular or ovoid. The strands from which these fibrous masses are formed run in two series. One series can be traced as a single large strand which runs vertically through the centre of the apical cap till it reaches the flat top of the columella. Here it breaks into as many strands as there are angles to the columella, one strand running along each of the grooves already described, to the angle, after which it ramifies to form the tangled masses around the top and sides of the columella, in conjunction with the fibres from the second series; this series can also be traced from the top of the fruit, the strands passing midway between those of the last series. The inner part of the third coat constitutes the locule-lining (Pl. XXIV, fig. 8) and, as already stated, is identical in character with the outer integument of the columella. Within the seed-pockets this integument is formed of two (?) layers of fibres (individual fibres being 0·016 mm.

wide); those of the inner layer are mostly transverse, but sometimes contorted, those of the outer layer are oblique or longitudinal. Hence these two layers overlying one another produce the criss-cross effect figured by Bowerbank (1840, pl. vii, fig. 5). When the fruit splits at the top, as it may do when the upper tier of seeds is infertile, it is this layer which lines the adjacent walls (cf. Pl. XXIV, fig. 8). The seed-pockets do not lie very accurately in vertical planes; those of the lower tier are more accurately aligned than those of the upper tier, which are often twisted out of the vertical. Hence the seeds may lie somewhat obliquely above the top of the columella. Length of fruit, 12 to 25 mm.; diameter, 9 to 17 mm.

Seed: Elongate, flattened dorsally at the hilar end, but terete in section and rounded at the chalazal end. Anatropous, with the hilum and chalaza terminal. The raphe lies along the dorsal surface close to one of the angular lateral margins, sometimes forming a short flange at the hilum (Pl. XXIV, figs. 13–16); it narrows considerably before it reaches the small chalaza. The testa is formed of an outer coat of large deep polygonal cells, about 0·05 to 0·075 mm. in diameter, very irregular both in form and alignment (Pl. XXIV, fig. 17), and of an inner coat (thickness unknown) composed of fine regular parenchyma, the cells being about 0·0125 mm. in diameter. The tegmen is preserved only in the impressions of its delicate-walled, large, flat, polygonal cells on the internal cast of the seed. The seeds in the lower tier are longer on the average than those in the upper. Length of typical seeds in lower tier, 8·5 mm.; breadth, 2·5 mm. Length of seeds in upper tier, 5 mm.; breadth, 2·5 mm.

REMARKS.—Nearly five hundred fruits or columellas in various stages of preservation, and many fragments. Also about thirty-six seeds removed or fallen from fruits. Usually the fruits have the exterior more or less worn, so as to expose one or another of the carpellary coats, seeds in their pockets, or portions of the columella. Not infrequently the detached columellas occur as separate entities completely divested of the pericarp, or with fragments of seeds and pericarp clinging to them (Pl. XXIV, figs. 9–12). The peculiar and varied forms which the columella may assume were admirably illustrated by Bowerbank (1840, pl. viii, figs. 37–47). In almost all specimens the substance of the columella has not been preserved, the space formerly occupied by it being now filled with structureless pyrites; but in a few it has been found (Pl. XXIV, figs. 8, 9).

According to the degree of abrasion of the fruit wall the appearance of the fossil varies so as to be very deceptive. Thus, as Bowerbank himself pointed out (1840, p. 29, pl. viii, fig. 27 at *a*), sometimes the knobs of the placenta are exposed through the worn carpel walls, when they simulate seeds (Pl. XXIV, figs. 10, 11), although they can always be distinguished from the true seeds by their structure. Sometimes when the pericarp is abraded and the placenta is exposed the seeds may have been worn or have fallen away leaving the intervening masses of fibres standing out as ribs or pillars and sometimes simulating seeds. When the apex of the fruit has been detached or abraded the five-rayed arrangement previously described is exposed (Pl. XXIV, figs. 5, 6). We have only seen the prismatic cells of the exterior on one specimen (Pl. XXIV, fig. 1). The longitudinal strands of fibres, too, are but rarely seen, for these, like many other features, such as the course of the bands of fibres in the endocarp, the raphe (Pl. XXIV, fig. 13), the mode of placentation and of the attachment of the seeds to the placental knobs (Pl. XXIV, figs. 10, 11), and the structure of the columella (Pl. XXIV, figs. 8–10), are only preserved under exceptional conditions, and even then can only be seen when differential decay has exposed them, or permits them to be exposed by dissection. It is difficult in hard pyritized material such as this to show by dissection the various delicate organs or features which it is desired to study; they are therefore seen best when exposed naturally by the partial disintegration or destruction of the fruits. The cells of testa and tegmen are often very clearly preserved; the cell-contents of the testa are replaced by golden pyrites, which gives a beautiful tessellated surface to the seed when the carbonaceous cell-walls have disappeared (Pl. XXIV, fig. 17). In section these pyritized masses separated by the carbonized cell wall present a series of small cubes. It is not easy to free the seeds completely without breaking them, unless the endocarp happens to be carbonized. In that case, however, the funicle and raphe have nearly always disintegrated, hence we have been able to expose them but rarely.

Affinities.—The interpretation of this peculiar fruit is most difficult. Bowerbank made a magnificent detailed study of it, which resulted nevertheless in conclusions which we cannot accept. His diagnosis of the genus is as follows: "*Pericarp* one-celled, valveless. *Placenta* central, usually five- rarely four- or six-angled, obconical and very large, with one or more seeds attached to each angle. *Seeds* and placenta enveloped in a mass of downy or filamentous structure, which fills up the whole of the remaining space within the pericarp. Seed about two or three times its own diameter in length, angular and somewhat curved. *Testa* reticulated."

At first sight our conclusion that the fruit is one-loculed is identical with that of Bowerbank. But actually it is not so. The locule we describe is not that postulated by Bowerbank, and our interpretation of the carpellary envelope is quite different from his. Consequently, whereas he suggests alliance with Malvaceae, we suggest it with Myrtaceae.

The significant character in the two diagnoses is the position and form of the locule. It must be remembered that almost always in fruits the inner wall of the endocarp surrounding the locules has a smooth lining layer of cells which gives a finished surface. We can find no such layer in the position to which Bowerbank assigns "the endocarpal membrane," exterior to the "downy structure," or as we prefer to call it, the mass of contorted fibres. But, on the contrary, we do find it lining the seed-pockets, covering the columella, and lining the wall of the carpel contiguous to it. It is composed, as described above, of a smooth layer of close, slender fibres, aligned horizontally, or slightly contorted. Such smooth fibrous layers constantly form inner walls of the endocarps adjacent to locules. The presence of this layer in the species under consideration indicates beyond a doubt that it delimits the locule, and if further confirmation be required it is found in the fact that it is this layer of the carpel wall which is in contact with the seeds. By tracing the course of the layer we find the fruit to be one-loculed. Bowerbank placed his locule external to the "downy structure" [contorted fibres] and regarded these as the locule-lining. The pericarp he figures and describes (1840, p. 27, pl. vii, fig. 1) as being formed of " thin epicarpal and endocarpal membranes, enclosing a cellular sarcocarp." His figure merely shows a coat of radially aligned prismatic cells with well-defined surfaces. (The fibre which he shows lying in the middle of the cells can have no structural significance.) The prismatic cells, as he explains, represent the sarcocarp ; the boundary lines must therefore represent his epicarpal and endocarpal membranes. But we have been unable to find any such actual membranes. The whole of Bowerbank's " pericarp " we have therefore described as the external coat of the carpellary envelope (1). Passing inward from this, Bowerbank states (p. 28) that " Surrounding the seeds and placenta, and filling up the whole remaining space in the interior of the pericarp, we find a mass of closely-compressed downy fibres," but he further states that " very frequently the filaments present a flattened appearance, as at *a*, fig. 5, plate 7, from their having been in a state of close compression, and this is more frequently the case in the neighbourhood of the sides of the placenta than elsewhere." Thus he evidently saw the smooth locule-lining but confused it with the mass of contorted fibres exterior to it, and he missed seeing the coat of radially aligned parenchyma overlying the fibrous masses. It was the misinterpretation of these fibrous envelopes, which he regarded as hairs, which led Bowerbank to suggest relationship with Malvaceae.

Any discussion as to the affinity of this fruit must depend fundamentally on the interpretation of the columella and its relation to the pericarp, *i.e.* whether the fruit is one-loculed or multilocular. The fact that the same fibrous coat has been traced completely over the placental mass and over the opposed face of the carpel, including the pockets in which the seeds lie and the contiguous surfaces of the loculicidal valves, constitutes, in our opinion, a sufficient proof that there can be only one locule in the ripe fruit, and that the fruit is therefore a five (or, occasionally, a four- or six-) carpelled syncarpous fruit, one-loculed, dehiscing by five (or four, or six) loculicidal valves, with axile placentation, the placentas being at the angles of a swollen columella, each placental angle bearing from one to four anatropous seeds, the upper seeds being erect, the lower pendulous. The only family in which we have been able to find such fruits is the Myrtaceae, including the sub-family Lecythidaceae. Other families which at first sight seemed possible, have had to be rejected from one cause or another. These were the Tiliaceae, Ternstroemiaceae, and Meliaceae. The Tiliaceae, we found by study in Kew Herbarium, showed no points of resemblance either in carpellary structure or placentation. In the Ternstroemiaceae, section Theeae (Szyszylowicz), the columella is flat at the top, and of somewhat similar shape, but very much smaller, except in *Caraipa* Aubl. where it is very large, and three-flanged, but not at all like the placental mass of *Hightea*. In Ternstroemiaceae the flanges or arms of the columella do not pass into the locules (seed-pockets of fossil), but are opposite to the septa. In *Medusagyne* Baker, of this family, two seeds are given off from the same placenta, one erect and the other pendulous, but otherwise there is no resemblance to *Hightea* ; the raphe may be either dorsal or lateral in the family. But with all these possibilities there are no fruits in this family which in any way recall *Hightea*. The Meliaceae again, besides being excluded by the ventral raphe, have no resemblance except general shape and the number of carpels.

In the Myrtaceae the same number of carpels may occur; a large flat-topped columella is sometimes found (*Xanthostemon* F. Muell.); the columella in the section Lecythidaceae becomes free from the carpel wall when the fruit is ripe, and forms a finished entity as in *Hightea*; the placentation may be similar. Thus in *Xanthostemon*, a five-carpelled fruit, the columella is five-armed, the arms forming the actual placentas to which numerous seeds are attached, some of the seeds lying along the sides of the rayed placental mass, and some above it. Unlike *Hightea*, however, the fruits of *Xanthostemon* are five-loculed and the angles of the placenta are not opposite to the locules (equivalent to the seed-pockets of *Hightea*), but lie opposite to the septa with which they are united in the unripe fruit. The inner layers of the carpel walls of many genera are formed of transversely aligned fibres, and the outer layers of contorted fibres and parenchyma. Many genera shed their seeds through loculicidal valves above the placental mass, an arrangement similar to that in *Hightea*, where the valves split apart opposite the seed-pockets; finally the testa is comparable in character with many Myrtaceae, which have a thin external coat of irregular, inflated cells, followed by a coat of closer texture, as in *Hightea*. The evidence, therefore, points to the alliance of the fossil species with Myrtaceae, but as we have been unable to refer it to any living genus, we have retained Bowerbank's generic name. It may, however, be mentioned in this connexion that we have been unable to study more than the outside of some of the living fruits which by their external characters suggest a possible relationship with the fossil species.

The great abundance of the fruits in the London Clay of Sheppey, viewed in association with the form and structure of the large columella, formed as it is of coarse parenchyma, suggests that the fruit was adapted for floating.

We have been able to identify very few of Bowerbank's figured specimens. This may result from changes incident on decay, which have made them unrecognizable; or it may be that they have completely decayed and no longer exist. In any case, out of all the numerous fruits which have still survived, two only of the figured specimens have been recognized. Several jars of these fruits were labelled *Hightea* by Ettingshausen, but some of these contained fruits with quite other affinities (*Protocommiphora europaea*, *Dracontomelon subglobosum*, *Langtonia bisulcata*, *Mastixia cantiensis*, and *Neuroraphe obovatum*). On the other hand, jars containing *Hightea* fruits were labelled *Livistona eocenica* and *Wetherellia variabilis* by Ettingshausen.

V. 22925 Holotype, figured Bowerbank (1840, pl. viii, fig. 9). A fruit, sectioned longitudinally through the columella.

V. 22911 Figured Pl. XXIV, fig. 1. A fruit with remains of the epicarp.

V. 22912 Figured Pl. XXIV, fig. 2. A fruit with the epicarp abraded, showing the longitudinal fibres.

V. 22913 Figured Pl. XXIV, fig. 3. A fruit with stalk detached.

V. 22914 Figured Pl. XXIV, fig. 4. A fruit, showing the tendency to dehisce by apical splitting; two valves only remain at the apex of the fruit.

V. 22915 Figured Pl. XXIV, fig. 5. A detached columella, showing the apical holes for the egress of fibres in the inner angles of the lobes.

V. 22916 Figured Pl. XXIV, fig. 6. A fruit with apex detached to show the apex of the placental mass. Also a seed detached and figured Pl. XXIV, fig. 17, to show the cells of the testa.

V. 22917 Figured Pl. XXIV, fig. 7. A fruit, stalk detached; it has been rubbed down so as to expose a longitudinal section through the columella. A seed is sectioned on the right. The fibres of the placenta can be seen. Also figured by Bowerbank (1840, pl. viii, fig. 11) as *Hightea elegans*. Labelled by Ettingshausen "*Livistona eocenica*."

V. 22918 Figured Pl. XXIV, fig. 8. A fruit, fractured longitudinally, showing the parenchyma of the placenta, the lining layers of the seed-pockets and locule, and one of the seeds.

V. 22919 Figured Pl. XXIV, fig. 9. A columella, fractured longitudinally, showing the parenchyma and the course of the branching fibres.

V. 22920 Figured Pl. XXIV, figs. 10–12. A fruit, much abraded so that the knobs of the columella project through the carpel wall and the seeds are exposed. Two erect seeds are attached at one angle of the placenta. At another angle one erect seed shows very clearly the hilum and mode of attachment, the proximal portion of the raphe, and the short funicle.

V. 22921 Figured Pl. XXIV, fig. 13. A seed, with the raphe near the lateral edge of the dorsal surface.

V. 22922 Figured Pl. XXIV, fig. 14. A seed, figured in side view.

V. 22923 Figured Pl. XXIV, fig. 15. A seed, showing the flange associated with the hilum and raphe, ventral side.

V. 22924 Figured Pl. XXIV, fig. 16. A seed, dorsal side.

V. 22926 A small detached seed.

V. 22927 A detached seed showing the raphe.

V. 22928 Two detached columellas, one fractured longitudinally, the other showing the fibre bands belonging to the carpel wall, between the angles where the seeds are attached.

V. 22928*a* A detached columella with slender stalk and prominent angles.

V. 22928*b* A detached columella with short stalk and conical form. The attachment, raphe, and funicle of one seed are clearly shown.

V. 22929 Two columellas, showing the parenchyma of which they are formed. V. 22929 is fractured longitudinally. V. 22929*a* is fractured transversely and has begun to break longitudinally also.

V. 22930 Fifteen well-preserved typical specimens; some are fruits and some are merely columellas with or without seeds. They vary in form, and some show the arrangement of the seeds on the placentas.

V. 22931 Two fruits rubbed down longitudinally, showing the columellas and one or two of the seeds.

V. 22932 A four-angled columella, evidently derived from a four-carpelled fruit.

V. 22933 Three hundred fruits.

V. 22934 One hundred and thirty detached columellas.

V. 22935 Thirty detached seeds.

V. 22936 A columella, probably of *Hightea elliptica.*
All the above are from the Bowerbank Coll., Sheppey.

V. 22937 A fruit. *Toulmin Smith Coll.*, Sheppey.

V. 22938 Seventeen fruits or columellas. *Reid & Chandler Coll.*, Sheppey, 1928, 1929.

V. 22939 Two fruits. *D. J. Jenkins Coll.*, Herne Bay.

Hightea turgida Bowerbank

PLATE XXIV, figs. 18–26.

1840. *Hightea turgida* Bowerbank, p. 41, pl. vii, fig. 27; pl. ix, figs. 1–8.
1879. *Hightea turgida* Bowerbank: Ettingshausen, p. 395.

DIAGNOSIS.—Fruit globular; sides of columella markedly concave, narrowing suddenly into the stalk; typical erect seeds: length, 10 mm.; breadth, 3·3 mm.

DESCRIPTION.—*Fruit:* Like that of *H. elliptica* in all its essential characters, but differing from that species in its globular, not sub-globular, form (Pl. XXIV, figs. 18–23), its normally large size and more sharply-angled, stipitate columella, which rapidly broadens above the stalk (Pl. XXIV, fig. 24). Diameter from 15 to 20 mm.

Seed: Similar to that of *H. elliptica*, but on the whole slightly longer and broader. A seed from the top of the placenta measured: length, 10 mm.; breadth, 3 mm.

REMARKS.—The species is much less common than *H. elliptica.* It is represented in the Bowerbank Collection by about seventy specimens, of which about fifteen are columellas. Bowerbank states that the seeds are few, and that he has " in no case seen them beneath the projecting terminations of the angles at the apex of the placenta." We have seen them in this position, and find that, as in *H. elliptica*, as many as four seeds may be developed at each angle.

V. 22940 Figured Pl. XXIV, fig. 18. A fruit, much worn, figured to show the side. Seeds, or their pockets, and placental knobs are exposed through the abraded wall.
V. 22941 Figured Pl. XXIV, fig. 19. A fruit, splitting at the apex.
V. 22942 Figured Pl. XXIV, fig. 20. A fruit, figured to show the base, with an aperture for the stalk.
V. 22943 Figured Pl. XXIV, fig. 21. A fruit, much abraded; the apex has come away, exposing the top of the columella and the upper tier of seeds lying upon it.
V. 22944 Figured Pl. XXIV, fig. 22. A worn fruit, showing the placental angles and some of the seeds protruding through the walls.
V. 22945 Figured Pl. XXIV, fig. 23. A fruit, broken so that the columella is exposed.
V. 22946 Figured Pl. XXIV, fig. 24. A columella detached from a fruit, showing the stipitate base and the sudden widening of the mass above.
V. 22947 Figured Pl. XXIV, fig. 25. A detached columella with broken base, figured to show the apex and the twin knobs which constitute the actual placentas.
V. 22948 Figured Pl. XXIV, fig. 26. An abraded fruit with placental knobs and seeds exposed. The raphe, funicle, and placentation are clearly shown.
V. 22949 A typical, but somewhat distorted and abraded fruit.
V. 22950 A typical fruit, broken to show the columella.
V. 22951 Fifty fruits.
V. 22952 Twelve detached columellas, a few fractured to show the structure. Probably they belong to *H. turgida*.

All are from the Bowerbank Coll., Sheppey.

Family CORNACEAE

Section *MASTIXIOIDEAE*

At the present time the section Mastixioideae is represented by a single genus, *Mastixia*, which is a one-loculed fruit. In the London Clay it is represented not only by *Mastixia* itself, but by three extinct genera all of which have more than one locule. We feel compelled to unite the one-loculed and the two- or more-loculed genera in one section, because (with the exception, in the case of *Langtonia*, of a difference in the dorsal infold) the structure of these nuts as well as of the seeds is, in all essentials, identical. That there is justification for such a course is further shown by the parallel evidence from Sparganiaceae (Reid & Chandler, 1926, p. 63, pl. iii, figs. 13–17) and from Nyssaceae (see p. 429), which indicates that in these families, also, there has been suppression of locules in some of their genera with the course of evolution.

Taking this broader definition of the section, to include fruits with more than one locule, we may state that in all genera the nuts have thick woody walls the inner layers of which, namely, those nearest the locules, are formed of concentrically disposed layers of fibres, those of the inner layer, lining the locule, being transverse. In all the genera the locules are straight, V-shaped in cross-section in *Mastixia*, *Beckettia*, and *Lanfrancia*; W-shaped in *Langtonia*. In all genera alike the dorsal infold, or infolds, of the endocarps, which produce the peculiar cross-section of the locule affects the whole thickness of the endocarp wall, its outer as well as its inner face, but, except in decay, it is not apparent on the outer face because it is masked by an infilling of loose tissue. The infolded dorsal face in all genera forms a conspicuous large valve which is concerned with germination and extends almost the full length of the nut. In all genera the seeds are pendulous and anatropous, with ventral raphe and small terminal chalaza. In all, the outer coat of the testa is formed of large cells (secreting in some genera, *e.g. Mastixia, Langtonia,* possibly in all). In all genera the tegmen cells are alike and transversely aligned.

Our first impression on examining these fossils was that they were related, as was subsequently demonstrated, to the Mastixioideae. But a statement by Lubbock (1892, p. 43) that the raphe in the Cornaceae is either dorsal or lateral misled us for a time. We therefore made a prolonged search through various other angiospermous families, but after having failed to discover any other nuts so like the fossils as those of *Mastixia* we were impelled to make an independent investigation of the seed-characters in living genera of the Cornaceae. We therefore dissected specimens of *Cornus* Linn., and *Mastixia* Blume, and discovered that whereas in *Cornus* the raphe is lateral or dorsal, in *Mastixia* it is ventral. We subsequently discovered that these facts had been noted by Harms in Engler's Pflanzenfamilien, although he was uncertain whether the raphe in *Cornus* could be anything but dorsal. It was thus proved beyond dispute that there was nothing in the position of the raphe to debar the fossils from belonging to the Cornaceae.

We have previously remarked on the fact that the fruits of the Mastixioideae and Nyssaceae have many characteristics in common (p. 429). In both there are woody endocarps which germinate by the opening of a dorsal valve or valves. In both the seed is solitary in the locule, pendulous, and anatropous, with median ventral raphe. In both the inner surface of the tegmen (or testa) is characterized by elongate cells with a very definite transverse alignment. In both the testa displays a marked tendency to adhere to the locule wall rather than to the seed, which tendency is clearly shown in the fossils referred to the two families in question. The large number of common characteristics above indicated is so striking as to suggest that there must be a close relationship between the two groups Mastixioideae and Nyssaceae. Harms (in Engler, 1898, III, viii, p. 255) supports such a relationship by placing the two groups as sub-divisions of the one family Cornaceae. But subsequently Engler & Gilg (1912, pp. 280, 290) treated the Nyssaceae as a distinct family belonging to a different order and separated from the Cornaceae by several families—Combretaceae, Myrtaceae, etc.

Genus MASTIXIA Blume

1825. Bijdr., p. 654.

Mastixia cantiensis n. sp.

Plate XXV, figs. 1–6.

Diagnosis.—Length of endocarp, 14 to 22 mm.

Holotype.—V. 22953.

Description.—*Fruit:* A large, ovoid, one-celled, one-seeded drupe. Endocarp with a single deep longitudinal infold on the dorsal wall, which projects into the locule causing it to be U-shaped in transverse section (Pl. XXV, fig. 4). As in *Mastixia*, the infold forms the inner face of a large dorsal germination valve reaching almost the full length of the nut, the outer face of which bears a corresponding groove filled with loose tissue. Wall of endocarp thick, woody, outer surface rough and nodular, covered by a coarse network of branching and anastomosing fibres which lie in the depressions between the nodules. External layers of the wall formed of radially aligned elongate cells (or fibres ?) with spiral or annular thickening. These layers pass gradually into a considerable thickness of coarse parenchyma within which are many concentric layers of fibres surrounding the locule, those of the innermost layer being in part transverse and in part oblique. Associated with the lining layers are branching and anastomosing fibres having a general longitudinal direction ; these originate from a strand of fibres which enters the locule at the apex. Length of endocarp, 14 to 22 mm. ; diameter, 7 to 9 mm. Thickness of endocarp wall as much as 3·5 mm. ; thickness of outer layer of wall with radially aligned cells, 2 to 3 mm.

Seed : Pendulous from the apex, conforming in shape to the locule, semicylindric with a longitudinally convex ventral face (Pl. XXV, fig. 6) and a concave dorsal face, lunate in transverse section, anatropous with adjacent hilum and micropyle, thick ventral raphe (Pl. XXV, fig. 5), and terminal chalaza—a small circular scar from which the tegmen cells radiate, and around which they are also concentrically arranged. Testa formed of several layers of large irregular cells, 0·025 to 0·05 mm. in diameter, with shining black infillings, the innermost layer of these cells being aligned transversely. Lining of testa (or tegmen ?) formed of large, flat, thin-walled cells, about 0·025 to 0·03 mm. in diameter, with parallel sides, either square, oblong, or faceted at the ends ; these cells are aligned accurately in rows, so that the internal surface is finely striate transversely, the striations forming concentric rings around the chalaza and micropyle. Length of a seed, 12 mm. ; breadth, 6·5 mm.

REMARKS.—Remains of about twenty specimens, and a number of fragments, from Sheppey and Herne Bay. All the larger endocarps were much decayed and broken. The comparison of these specimens was difficult because the coats were differently preserved and decayed, even in the various parts of the same specimen. Thus part of the radial fibres of the endocarp wall may be either carbonized or pyritized, or entirely missing, their place being taken either by a mass of pyrites or by a hollow. Similarly with the other tissues. A few of the smaller specimens, although abraded externally, show the internal structure well preserved. Part of the apparent variation in size is doubtless due to differences in decay and abrasion. One specimen collected by Mr. Jenkins at Herne Bay, coated with pyrites, may retain part of the mesocarp, as the carpel wall appears exceptionally thick, and is formed towards the exterior of large secreting cells radially aligned. This is, however, an extremely doubtful interpretation, as no definite line of demarcation can be traced between the mesocarp and endocarp when the specimen is seen in section. This species may have been figured by Parkinson (1804, pl. vi, figs. 4, 8, and possibly 26). His fig. 8 seems to represent an endocarp, with the valve removed.

AFFINITIES.—There can be no doubt at all that these specimens belong to the genus *Mastixia*. The whole structure of fruit and seed and the remarkable germination valve are in absolute agreement with what is found in the fruits of that genus. *Mastixia* includes trees and shrubs occurring throughout the whole Indo-Malayan region, and found also in southern Yunnan.

The genus has been recorded fossil by C. & E. M. Reid in the Lignites (Middle Oligocene ?) of Bovey Tracey, Devonshire (1910, p. 166, pl. xvi, figs. 73, 74). Two allied genera (*Mastixicarpum crassum*, and *Eomastixia bilocularis*) were described by M. E. J. Chandler from the Upper Eocene of Hordle, Hants (1926, pp. 36, 37, pl. vi, figs. 5, 6).

A few specimens were in a jar with other Cornaceae labelled "*Hightea* Bowerb." by Ettingshausen.

V. 22953 Holotype, figured Pl. XXV, figs. 1, 2. An endocarp, fractured longitudinally to show the seed and the thick carpel walls. One of the halves has been fractured transversely so that the form of the locule can be seen.
V. 22954 Figured Pl. XXV, fig. 3. An endocarp, fractured to show the ventral face of the locule-cast (which in form resembles the seed).
V. 22955 Figured Pl. XXV, fig. 4. An endocarp, fractured transversely to show the form of the locule with its median infold.
V. 22956 Figured Pl. XXV, fig. 5. An imperfect locule-cast, chipped at one end to show the seed-cast within with its ventral raphe.
V. 22957 Figured Pl. XXV, fig. 6. A detached, internal cast of a seed with remains of the external cast. The seed-cast is broken longitudinally.
V. 22958 An endocarp, fractured longitudinally. It shows the internal cast of the seed with its tegmen; the testa can also be seen in a small patch.
V. 22959 An endocarp, broken longitudinally and transversely. It shows part of the seed-cast.
V. 22960 Two endocarps, much shattered.
V. 22961 Six seeds or locule-casts.
V. 22962 One seed with locule-cast adhering, probably referable to this species.
V. 22963 Twenty fragments of endocarps and locule-casts. A few of these were in a jar labelled by Ettingshausen "*Hightea* Bowerb."
All the above are from the Bowerbank Coll., Sheppey.
V. 22964 A specimen encrusted with pyrites, fractured to show the structure. The wall may, in part, represent mesocarp. *D. J. Jenkins Coll.*, Herne Bay.
V. 22965 An endocarp, fractured longitudinally. *Toulmin Smith Coll.*, Sheppey.
V. 22966 Three seeds and one valve. *Reid & Chandler Coll.*, Sheppey, 1928.
V. 22967 Two abraded endocarps. *D. J. Jenkins Coll.*, Herne Bay.

Mastixia grandis n. sp.

PLATE XXV, figs. 7–9.

DIAGNOSIS.—Length of endocarp, 27·5 mm.; distinguished from *M. cantiensis* by its greater size.

HOLOTYPE.—V. 22968.

DESCRIPTION.—*Fruit:* A large, ovoid, one-celled, one-seeded drupe. Mesocarp, preserved only in a few small patches, formed of very coarse parenchymatous cells of regular honeycomb shape. Endocarp with a single deep longitudinal infold which projects into the locule, thereby causing it to be lunate in section. As in the living genus *Mastixia*, the infold forms the inner face of a large dorsal germination valve (Pl. XXV, fig. 9) the outer face of which bears a corresponding groove filled with loose tissue (Pl. XXV, fig. 7). The wall of the endocarp is thick, perhaps in parts as much as

4 mm. Its outer surface is rough and nodular and covered by a coarse network of branching and anastomosing fibres. The external layers are formed of a great thickness (2 to 3 mm. ?) of fibres aligned radially which, as they pass within, gradually merge into a considerable thickness of coarse parenchyma. Within this parenchyma are many layers of fibres aligned parallel to the surface of the locule, which surface shows a system of branching and anastomosing bands of fibres associated with a smoother coat of fibres, aligned in part transversely and in part obliquely. Length of endocarp (with some of the mesocarp still clinging to it ?), 27·5 mm. ; greatest diameter, 17 mm. ; least diameter, 13 mm.

Seed : Conforming to the locule in shape, lunate in section, the ventral face being convex, the dorsal face concave. Characters not well seen, micropyle terminal at one end, hilum, raphe, and chalaza not visible Testa poorly preserved so that the cells cannot be clearly distinguished, tegmen smooth and shining, formed of delicate, thin-walled, transversely aligned cells with parallel sides and truncate or faceted ends, aligned concentrically around the micropyle, 0·025 to 0·03 mm. long, and 0·05 mm. broad.

REMARKS.—Two specimens. The better preserved broke when fractured, in part irregularly and in part regularly, along the planes of weakness at the margins of the valve. The surface of the fruit is much encrusted with pyrites on one side. This pyrites may have replaced the decayed mesocarp to some extent, as fragments of its large honeycomb cells remain embedded in it here and there. The soft tissue which formerly filled the groove on the dorsal valve has decayed very unevenly, leaving an irregular longitudinal depression with a mass of pyrites in the middle, and with ragged edges (Pl. XXV, fig. 7). The second specimen appears to be a more worn and decayed endocarp of the same species. It shows the decayed remains of a seed, and the well-preserved germination valve (Pl. XXV, fig. 9).

AFFINITIES.—That the specimens belong to the genus *Mastixia* is indubitable. Every character described above points to this relationship. It is distinguished from the preceding species by its great size.

V. 22968 Holotype, figured Pl. XXV, figs. 7, 8. An endocarp, much broken, showing the internal cast of the locule and seed, both imperfect.

V. 22969 Figured Pl. XXV, fig. 9. A broken endocarp ; the valve has come away and is broken transversely.

Both are from the Bowerbank Coll., Sheppey.

Mastixia parva n. sp.

PLATE XXV, figs. 10–17.

1879. *? Cyperites eocenicus* Ettingshausen, p. 393.

DIAGNOSIS.—Length of endocarp, 7 to 10 mm. ; distinguished from *M. cantiensis* and *M. grandis* by its small size.

HOLOTYPE.—V. 22970.

DESCRIPTION.—*Fruit :* Small, inferior, ovoid, with a few longitudinal furrows (possibly associated with fibres), one-loculed, one-seeded, with a circular scar at the apex marking the limit of the accrescent calyx (Pl. XXV, fig. 11). Epicarp smooth and shining, formed of square or rectangular cells, 0·05 mm. in diameter. Mesocarp between 0·6 and 0·9 mm. thick, formed of polygonal or rounded cells, many of which are 0·03 mm. in diameter, with shining contents and thin double walls (glandular ?).

Endocarp: Ovoid, probably ridged or angled externally in its unworn condition (in Pl. XXV, fig. 12, these ridges are seen near the top of the figure standing out sharp and dark against the white pyritized mesocarp). Dehiscing by a large, longitudinal, dorsal valve with a median longitudinal groove on its external surface (Pl. XXV, fig. 13). The groove corresponds with a deep longitudinal infold projecting into the locule as a rounded ridge (Pl. XXV, figs. 14, 15). Endocarp wall thick, formed by a layer of variable thickness, of transversely aligned elongate cells and parenchyma. Within the wall are embedded a few longitudinal strands of fibres which seem occasionally to branch and anastomose. Two of these strands outline the valve, which is large (Pl. XXV, figs. 10, 13, 14, 16). Within is a layer, of uniform thickness, several cells thick, formed of horizontally aligned fibres. These form the locule-lining, which is transversely striate (Pl. XXV, fig. 16). The depression of the infold is occupied by coarse parenchyma which seems to have had a spongy texture. It is often decayed and replaced by structureless pyrites (Pl. XXV, figs. 13–15). Length of fruit (imperfect), 14·5 mm.; breadth, 7 to 9 mm.; length of endocarp, 7 to 10 mm.; average diameter, about 4 mm.

Seed: Conforming to the shape of the locule, semi-cylindric, with a convex ventral face and concave dorsal face, the transverse section being lunate. Testa several cells thick of coarse, irregular cells 0·05 to 0·1 mm. in diameter, containing a black, bituminous-looking substance. Lining of testa (or tegmen ?) of thin-walled cells, 0·025 to 0·05 mm. long, 0·025 mm. broad, aligned in regular transverse rows.

AFFINITIES.—About seventy specimens, some fragmentary, from Sheppey, and three from Herne Bay. The majority have suffered much abrasion and have lost most of the carpel wall. One specimen only, collected by Mr. D. J. Jenkins at Herne Bay, shows the mesocarp and epicarp (Pl. XXV, figs. 11, 12). Owing to their poor condition only a few of the endocarps show clear evidence of the valve. There can be no doubt that this small species belongs to the family Cornaceae and to the section Mastixioideae. In the genus *Mastixia* all its characters are found, but it is smaller than any living species.

V. 22970 Holotype, figured Pl. XXV, fig. 10. An endocarp.

V. 22971 Figured Pl. XXV, figs. 11, 12. A fruit with mesocarp and epicarp preserved, fractured to show the endocarp and seed. *D. J. Jenkins Coll.*, Herne Bay.

V. 22972 Figured Pl. XXV, fig. 13. A somewhat abraded endocarp, showing the germination valve with its longitudinal infold. The cells, which in the perfect fruit occupy the infold, have decayed and their place has been taken by structureless pyrites.

V. 22973 Figured Pl. XXV, fig. 14. An endocarp, fractured transversely; the pyrites which fills the infold is seen as in V. 22972.

V. 22974 Figured Pl. XXV, fig. 15. An endocarp, fractured transversely to show the form of the locule and the infold.

V. 22975 Figured Pl. XXV, fig. 16. A locule-cast showing the groove which marks the former position of the infold. A longitudinal ridge of pyrites on each side of this groove marks the original boundaries of the valve. The ridges have been formed by the infiltration of pyrites into the fissures formed by the opening valve. After decay of the soft carbonaceous endocarp, the infiltrated matter has remained as ridges on the locule-cast.

V. 22976 Figured Pl. XXV, fig. 17. An internal cast of a seed with adherent remains of the endocarp at one end.
V. 22977 An endocarp.
V. 22978 Two locule-casts.
V. 22979 Twenty endocarps.
V. 22980 Two endocarps, both fractured longitudinally. These were labelled by Ettingshausen "*Cyperites* sp."

All the above except V. 22971 *are from the Bowerbank Coll.*, Sheppey.

V. 22981 A well-preserved unabraded endocarp. *D. J. Jenkins Coll.*, Herne Bay.
V. 22982 An endocarp. *D. J. Jenkins Coll.*, Herne Bay.
V. 22983 Twenty-eight endocarps. *Reid & Chandler Coll.*, Minster, 1929.

Genus LANGTONIA nov.

Diagnosis.—Endocarp ovoid, two-loculed, with one seed in each locule, syncarpous, germination valves each with a pair of longitudinal infolds; locule and seeds W-shaped in cross-section; raphe ventral. Length of endocarp, 9 to 20 mm.; diameter, 4·5 to 12 mm.

Genotype.—*L. bisulcata* n. sp.

Langtonia bisulcata n. sp.

Plate XXV, figs. 18–27.

Diagnosis.—That of the genus.

Holotype.—V. 22984.

Description.—*Endocarp:* Syncarpous, two-loculed, ovoid, often with only one locule fully developed (Pl. XXV, figs. 18, 19, 22). Two deep longitudinal infolds of the carpel wall project into each locule on the dorsal face, giving it a somewhat W-shape in cross-section (Pl. XXV, figs. 19, 22, 23). Germination takes place by the throwing off of a large dorsal valve from each locule, the valve bearing on its inner face a pair of longitudinal ridges formed by the infolds described above (Pl. XXV, fig. 25). Each valve occupies the whole breadth and almost the whole length of the locule. Carpel wall formed of two coats; the inner coat consists of several (probably eight or nine) layers of fibres, with spiral or annular thickening (we could not be sure which). The fibres are variously aligned, although the majority lie almost transversely; those of the innermost layer, which form the locule-lining, are strictly horizontal over the whole surface of the locule, including the surface of the valve. Associated with this layer, but exactly how we do not know, is a system of large fibres which, entering at the apex of the locule, branch freely over the whole ventral surface, but rarely anastomose (Pl. XXV, fig. 26). The outer coat of the endocarp, which is of variable thickness, fills the hollows formed by the infolds and the angular spaces between the locules, in the latter case forming thick masses, sub-triangular in section. The cells of which this coat is built are large and tortuous, variously aligned, but directed, for the most part, radially, more especially towards the periphery of the endocarp. Length of endocarp (largest), 20 mm.; diameter, 12 mm.; length of a second endocarp, 18 mm.; diameter, 14 mm.; length of a third, 15 mm.; diameter, 8 mm.; length of smallest endocarp, 9 mm.; diameter, 4·5 mm.

Seed: Solitary in each locule, conforming to the shape of the locule, semi-cylindrical on the ventral face and with two large, deep, longitudinal grooves on the dorsal face (Pl. XXV, fig. 27), usually rather broader at the chalazal end, pendulous, anatropous, with a conspicuous broad raphe median on the ventral face (Pl. XXV, fig. 21). Chalaza and hilum terminal at opposite extremities, the hilum and micropyle being at the end nearest the top of the fruit. Testa formed of one, or sometimes of two layers of very large cells, which may measure from 0·03 to 0·1 mm. or more in diameter; they appear to have been filled with some resinous or oily substance now represented by dark, glistening cell contents; in this layer the raphe is embedded. Tegmen formed of large, flat, thin-walled cells, usually oblong or square, but sometimes angled and faceted, aligned in definite transverse rows; the cells measure from 0·01 to 0·025 mm. in diameter. The dimensions of the seeds are very variable, depending in part on the degree of development. Length of a well-developed seed, 12 mm.; breadth, 6 mm.; depth, 4·5 mm.

REMARKS.—Seventy-six specimens and a number of fragments. The specimens differ considerably in appearance according to the amount of abrasion they have undergone. The locule-casts may be exposed to a greater or lesser degree, for as they are formed of hard pyrites they are more resistant than the partly carbonaceous carpel wall. Sometimes, after the germination valves have become detached, these locule-casts fall out. As is usual with one-seeded locules, the locule-cast reproduces very clearly the form of the seed (Pl. XXV, fig. 27). Some casts have the transversely striate lining of the locule adhering to them, others the branching fibres (Pl. XXV, fig. 26). Some of the seed-casts, which are similar in form, are covered by the large cells of the testa with the embedded raphe; in others the testa is worn away, leaving the seed-cast with the tegmen cells upon its surface. Transverse sections of the fruit show very clearly the relation of these various coats and organs. In one specimen only has the germination valve come away as a perfect entity so as to show its form clearly (Pl. XXV, fig. 25). Usually pyrites has percolated into the locule, enveloping the seed and cementing it to the valve, so that when the valve is detached, the locule-cast with the seed enclosed adheres firmly to it.

AFFINITIES.—In the general structure of its endocarp, and in that of the tegmen of its pendulous anatropous seeds, this valved fruit has characters which are common to some of the Nyssaceae (p. 429) as well as to *Mastixia*; but the long infolded valve at once excludes the Nyssaceae from comparison. There remains *Mastixia*. Although there are very close affinities in the general structure of endocarp and seed, yet there are essential differences. The living *Mastixia* is one-loculed; the fossil is two-loculed. The valve in *Mastixia* has but one infold; in the fossil it has two. In consequence the seed, which in both fruits corresponds to the shape of the locule, is U-shaped in cross-section in *Mastixia*; W-shaped in the fossil. The fossil species cannot therefore be united with *Mastixia*, although it is probably very closely allied to that genus.

In fully developed fruits of *Eomastixia* Chandler (1926, p. 37, pl. vi, fig. 6) there are two locules which in cross-section show an approach to the W-shape of the locule of *Langtonia ;* but unlike this the exterior of the endocarp shows no indication of two infolds. That is to say, although there is but a single infold, it is slightly expanded, and has a slight central longitudinal furrow. In *Eomastixia* the infold is very narrow externally. There are also differences in the structure of the carpel. Therefore, *Langtonia* cannot be referred to the fossil genus *Eomastixia*. Its relation to other London Clay genera of Cornaceae will be discussed as these are described. We have given it the name *Langtonia* in honour of Stephen Langton, Archbishop of Canterbury, 1207–1228.

V. 22984 Holotype, figured Pl. XXV, figs. 18, 19. An endocarp with one fertile and one abortive locule, fractured transversely to show the form of the locule and seed with the two longitudinal infolds and furrows. The valve of the abortive locule has come away in the upper half of the endocarp carrying with it the locule-cast.

V. 22985 Figured Pl. XXV, fig. 20. A two-loculed endocarp.

V. 22986 Figured Pl. XXV, fig. 21. An endocarp, fractured longitudinally to show the ventral surface of a seed with its testa and raphe.

V. 22987 Figured Pl. XXV, fig. 22. An endocarp with one fertile and one abortive locule, fractured transversely. The abortive locule has broken away. The ventral infolds are clearly seen.

V. 22988 Figured Pl. XXV, fig. 23. An endocarp with two developed locules ; the specimen has been fractured transversely so that the two locule-casts are clearly seen in transverse section.

V. 22989 Figured Pl. XXV, fig. 24. A detached valve with the locule-cast adhering to it on the ventral surface. On the dorsal surface the valve shows two longitudinal grooves, now filled with pyrites, which correspond with the two longitudinal infolds of the inner surface of the valve (concealed by the adhering locule-cast).

V. 22990 Figured Pl. XXV, fig. 25. A detached valve and the fruit to which it belongs. The valve shows the two longitudinal infolds on the inner surface.

V. 22991 Figured Pl. XXV, fig. 26. A locule-cast with branching fibres adhering to its ventral surface.

V. 22992 Figured Pl. XXV, fig. 27. A locule-cast, showing the ridges and furrows of the dorsal surface.

V. 22993 An endocarp with one fertile and one minute abortive locule. The endocarp has been fractured transversely, and shows the characteristic cross-section.

V. 22994 An endocarp, fractured longitudinally so as to show the ventral surface of the seed-cast within.

V. 22995 A two-loculed endocarp.

V. 22996 An internal cast of a seed, hilar end, broken along one margin and along the median dorsal ridge.

V. 22997 An internal cast of a seed, chalazal end.

V. 22998 Forty-five endocarps in various stages of abrasion ; a few are fractured longitudinally or transversely. Some were in a jar labelled by Ettingshausen "*Hightea* sp."

V. 22999 Twelve detached locule-casts.

V. 23000 Thirty fragments of endocarps or locule-casts.

All the above are from the Bowerbank Coll., Sheppey.

V. 23001 Six specimens. *Reid & Chandler Coll.*, Minster, 1929.

Genus BECKETTIA nov.

Diagnosis.—Endocarp sub-globular or ovoid, two- (rarely three- ?) loculed, syncarpous, germination valves each with a single infold ; locule and seed U-shaped in cross-section ; endocarp formed of parenchyma in the angles between the locules, some cells measuring 0·1 mm. in diameter ; raphe ventral. Length of endocarp, 13 to 15 mm. ; breadth, 11·5 to 13 mm.

Genotype.—*B. mastixioides* n. sp.

Beckettia mastixioides n. sp.

PLATE XXV, figs. 28–36.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 23002.

DESCRIPTION.—*Endocarp:* Two- (or rarely three- ?) loculed, syncarpous, frequently with only one locule developed; sub-globular or broadly ovoid, but with a simple, deep, longitudinal infold on the dorsal wall of each carpel; the infold, which is associated with the long valve of germination, projects into the locule making it U-shaped in transverse section (Pl. XXV, figs. 33, 34); the valve extends the full length of each locule. Endocarp wall thick and massive in the angles between the locules and within the infolds of the valves (Pl. XXV, figs. 33, 34). The interior of these masses is formed of very large globular or angular cells (many being 0·1 mm. in diameter), which are sometimes equiaxial; towards the periphery of the fruit the cells become very much smaller, and are aligned more or less radially; towards the locule they are long and are arranged in many concentric layers, the long axes of the cells being directed, for the most part, obliquely; in the layers nearest the locule elongate cells or fibres lie athwart one another, so that their superposed impressions give a criss-cross effect; those which form the locule-lining are directed obliquely downward from a median strand on the ventral surface (Pl. XXV, fig. 36), but become horizontal as they reach the dorsal surface (Pl. XXV, fig. 35). The impressions of the polygonal cells of the testa are also sometimes seen on the locule-cast, but these must not be confounded with the cells of the endocarp itself. Length of nut, 13 to 15 mm.; breadth, 11·5 to 13 mm.

Seed: Solitary, pendulous, conforming to the shape of the locule, semi-cylindric, being convex on the ventral face and concave on the dorsal, U-shaped in section; anatropous, with a median broad ventral raphe, hilum and micropyle at the end nearest the apex of the fruit, and chalaza at the opposite end. Testa formed of two coats: an outer coat formed of many layers of polygonal cells 0·05 mm. in diameter, as seen in impressions on the locule-cast, and with a columnar arrangement as seen in radial sections of the seed; an inner coat two cells thick of small obliquely aligned cells which produce a striate surface something like that of the locule-lining, but more finely striate. A coat of transversely elongate cells, about 0·05 mm. long, has also been seen. It appears to lie outside the tegmen, but its exact position is uncertain. Tegmen cells large, flat, thin-walled, accurately aligned in transverse rows, the cells being square, oblong, or faceted. Length of seed, 9·3 mm.; breadth, 5 mm.

REMARKS.—Seventeen specimens. All are highly pyritized and in consequence have not fallen into decay so as to expose the locule-casts and seeds, either as frequently or as clearly as in the case of the related genera of the section Mastixioideae.

AFFINITIES.—The relationship to *Mastixia* is clear, but the fossil is distinguished by its two locules, and by the mass of coarse parenchyma which mainly fills the angular spaces between the locules.

In regard to the related fossil genera, it is distinguished from *Eomastixia* Chandler (1926, p. 37, pl. vi, fig. 6) by its broader more marked infold, and by the form of the locule (and seed), which in *Beckettia* are U-shaped in transverse section, but in *Eomastixia* are somewhat W-shaped; also by its broader valve and greater space in the angles between the locules, occupied by coarse parenchyma.

From *Langtonia*, besides some differences in cell-structure, it is chiefly distinguished by the single, instead of double infold, and by the cross-section of locule and seed, which in *Beckettia* are U-shaped, but in *Langtonia* are W-shaped.

We deal with the differences between it and *Lanfrancia* under that genus.

The fruit has been named in honour of Thomas à Becket, Archbishop of Canterbury, 1162–1170.

V. 23002 Holotype, figured Pl. XXV, fig. 28. A two-loculed endocarp.
V. 23003 Figured Pl. XXV, fig. 29. A two-loculed endocarp, showing the valves very clearly as the result of partial decay.
V. 23004 Figured Pl. XXV, fig. 30. A two-loculed endocarp. The valves have fallen out or are abraded, exposing the locule-casts.
V. 23005 Figured Pl. XXV, figs. 31, 32. A three-loculed endocarp. One valve is detached to show the seed.
V. 23006 Figured Pl. XXV, fig. 33. An endocarp, fractured transversely to show one abortive and one fertile locule in section.
V. 23007 Figured Pl. XXV, fig. 34. An endocarp, fractured transversely to show two fertile locules, one of which is rather small.
V. 23008 Figured Pl. XXV, figs. 35, 36. A locule-cast.
V. 23009 A large, two-loculed endocarp.
V. 23010 A valve and locule-cast, the latter chipped away to show the seed lying within.
V. 23011 A valve and locule-cast.
V. 23012 Fragments of a broken fruit, showing an imperfect internal cast of a seed.
V. 23013 Six fruits in various states of abrasion and a number of imperfect fruits, fragments, valves, or locule-casts.

All are from the Bowerbank Coll., Sheppey.

Genus LANFRANCIA nov.

Diagnosis.—Endocarp ovoid, three- or four-loculed, syncarpous, splitting into pyrenes, formed of small elongate cells with sinuous alignment; germination valves each with a single longitudinal infold; locules and seeds U-shaped in cross-section. Length of endocarp, about 12 mm.; diameter, 9 mm.

Genotype.—*L. subglobosa* n. sp.

Lanfrancia subglobosa n. sp.

Plate XXV, figs. 37–40.

Diagnosis.—That of the genus.

Holotype.—V. 23014.

Description.—*Fruit:* Ovoid, syncarpous, three- or four-loculed, splitting into pyrenes (as a result of decay during fossilization ?), woody. Each locule has a simple, deep, longitudinal infold along its dorsal wall, which projects into the cavity, making it U-shaped in section. Germination takes place by the removal of a large dorsal valve which extends the full length of the locule and bears on its inner face the long protuberance of the infold. Carpel wall thick, formed of long tortuous cells aligned more or less horizontally, and intermingled with parenchyma; the wedges of cells in the angles between the locules are narrower than in *Beckettia*. Towards the locule the cells are arranged in concentric layers, and the locule-lining is formed of elongate cells or fibres which, after diverging obliquely from a median band of fibres on the ventral wall, become horizontal. Length of endocarp, 12 mm.; diameter, 9 mm.

Seed: Solitary, conforming to the locule in shape, semi-cylindric, convex on its ventral face, concave on its dorsal face, U-shaped in cross-section; pendulous, anatropous, with a thick median ventral raphe, the hilum and micropyle being terminal at the end turned to the apex of the fruit, and the chalaza terminal at the opposite end. Testa not clearly seen, but the impressions of the large cells of its outer surface are obscurely preserved on parts of the internal casts of the locules. Tegmen formed of large, flat, thin-walled cells aligned accurately in transverse rows, the cells being square, oblong, or faceted; they are about 0·015 to 0·016 mm. long. Length of locule-cast (virtually of seed), 10 mm.; breadth, 5 mm.; thickness, 4 mm.

REMARKS.—Seventeen specimens in various stages of preservation, one being almost perfect. In several the exterior of the fruit has been abraded leaving the locule-casts protruding through the carpel wall (Pl. XXV, fig. 37). One specimen was from Herne Bay, the remainder from Sheppey.

AFFINITIES.—The structure of this fruit and seed clearly point to its relationship with the Cornaceae, and more nearly with *Mastixia*, also with the extinct genera *Eomastixia*, *Langtonia*, and *Beckettia*. From *Mastixia* it differs in the greater number of its locules; from *Beckettia* in the greater number of its locules, also in the angular masses between the locules being formed of fine elongate cells with sinuous alignment instead of coarse parenchyma; from *Eomastixia* and *Langtonia* chiefly in the greater number of locules and in the form of the locules and valves. It is distinct from all the plurilocular genera in that, under conditions of fossilization at least, it may split into one-seeded cocci. Whether all these differences are of generic value it is difficult to decide. Perhaps the number of locules may not be; but it seems better to err on the side of too great separation of species into genera, rather than of too little. Genera can easily be combined if the necessary evidence is forthcoming. We have named the genus after Lanfranc, Archbishop of Canterbury, 1070–1089.

V. 23014 Holotype, figured Pl. XXV, figs. 37, 38. A four-loculed fruit, somewhat abraded so that the locule-casts are partially exposed.

V. 23015 Figured Pl. XXV, figs. 39, 40. A three-loculed endocarp. The carpels have been detached from one another. The specimen was in a jar with other cornaceous fruits labelled by Ettingshausen "*Hightea*."

V. 23016 Two fruits, fractured to show the carpels in section.

V. 23017 Four abraded fruits with locule-casts exposed.

The above are from the Bowerbank Coll., Sheppey.

V. 23018 Eight fruits in various states of abrasion. *Reid & Chandler Coll.*, Minster, 1929.

V. 23019 Two carpels of a fruit. *D. J. Jenkins Coll.*, Herne Bay.

Genus ? (CORNACEAE section *MASTIXIOIDEAE*)

PLATE XXVI, figs. 16, 17.

1879. *Livistona eocenica* Ettingshausen (? pars), p. 393.

DESCRIPTION.—Two locule-casts, to which thin films of the carpel wall still adhere, are U-shaped in cross-section, the hollow formerly occupied by the wide dorsal infold of the carpel wall being now filled with pyrites (Pl. XXVI, fig. 16); the ventral wall is obscurely fluted. On the surfaces of the casts are the remains of the lining layer of the locule, which shows transversely elongate cells with embedded longitudinal strands of fibres, as well as the impressions of the polygonal cells of the testa of the seed. The locules must therefore have been one-seeded, and the seeds must have conformed to their shape, being U-shaped in cross-section. Length of smaller locule-cast, 9·2 mm.; breadth, 4·5 mm. Length of larger, 12·5 mm.; breadth, 6·6 mm.

REMARKS.—Both specimens belong to the Bowerbank Collection. The shape of the locule-casts, and the character of the lining layer of cells, as well as of the cells of the testa indicate that the casts belong to the section Mastixioideae of the family Cornaceae, and very probably to *Mastixia* itself, for the locules are of the same form as those of *Mastixia*, and the cells of the lining layer and testa are similar. The flutings of the ventral face, if they are original and not the result of shrinkage (which they do not appear to be), make the casts unlike any others of the Mastixioideae with which we have met in the London Clay.

The specimens were labelled by Ettingshausen "*Livistona eocenica*."

V. 23020 Figured Pl. XXVI, figs. 16, 17. A locule-cast with a thin film of endocarp wall adhering.
V. 23021 A smaller locule-cast.
Both are from the Bowerbank Coll., Sheppey.

Section *CORNOIDEAE*

Genus DUNSTANIA nov.

DIAGNOSIS.—Endocarp woody, with secreting cavities; locules more than two; germinating by long valves from each locule without any infold; raphe dorsal.

GENOTYPE.—*Callitris Ettingshauseni* Gardner.

Dunstania Ettingshauseni (Gardner)

PLATE XXV, figs. 41–47.

1883. *Callitris Ettingshauseni* Gardner, p. 22, pl. ix, figs. 1–6.
1883. *Callitris curta* (Bowerbank): Gardner, p. 21, pl. ix, figs. 7, 8.

DIAGNOSIS.—Endocarp globular or ovoid with a small apical depression and conspicuous apical (funicular ?) canals, three- or four-loculed. Length, 14 mm.; diameter, 13 mm. Seed triangular in cross-section almost throughout its length. Length, 9 mm.; breadth of flat dorsal face, 3 mm.

NEOTYPE.—V. 23022.

Description.—*Endocarp :* Globular or ovoid, smooth externally, with a small depression at the apex ; three- or four-loculed, with one pendulous seed in each locule. Germination takes place by the opening of a large oval valve from the dorsal wall of each locule (Pl. XXV, figs. 41–43, 46) ; the valves are smooth and finished along their margin except at the base, where they break irregularly (Pl. XXV, fig. 46). From the small apical depression a deep groove runs into each locule (Pl. XXV, figs. 41, 42). These grooves are almost certainly the funicular canals and appear to form a constant feature, being always visible even in the relatively unabraded endocarps. They thus furnish one of the characters by which the species may be distinguished from the next described. Endocarp wall thick and woody, formed of large, short, thick, curved cells often with a highly contorted alignment, interspersed with large ovoid secreting cavities (Pl. XXV, figs. 44, 45), which are fewer in number than in *D. multilocularis* (p. 462). The margins of the germination valves and the lining layer of the secreting cavities are formed of very large irregular angular cells with sinuous walls which may measure as much as 0·2 or 0·3 mm. in diameter. The locule-lining is smooth, the cells seem to be narrow, with sinuous or sometimes digitate outlines ; they are transversely elongate and arranged in transverse rows, but their outlines are in most parts much obscured by the adhering testa. Length of endocarp, 14 mm. ; breadth, 13 mm.

Seed : Anatropous, with the hilum at the end nearest the top of the locule, and a conspicuous median dorsal raphe (Pl. XXV, fig. 47) ; the chalaza has not actually been seen, but its position as indicated by the raphe must be terminal, or almost terminal, at the end remote from the hilum. The seeds are relatively shorter and thicker than those of *D. multilocularis* next to be described, more markedly triangular in cross-section throughout the greater part of their length, with a broader dorsal flattening under the valve (Pl. XXV, fig. 47), compressed dorsi-ventrally at the hilar end, and to some extent at the chalazal end also, whereas the seeds of *D. multilocularis* (cf. Pl. XXVI, fig. 15) are attenuated at the hilar end into the funicle and terete at the chalazal end. The testa is fused with the locule wall ; its cells are polygonal, lozenge-shaped, or sometimes irregular, they measure from 0·025 to 0·05 mm. in diameter. The cells of the tegmen are thin-walled and irregularly angular ; they are very obscure, but cells of this character are clearly seen forming the tegmen in the next species to be described. Length of seed, 9 mm. ; breadth across dorsal face, 3 mm.

Remarks.—Six endocarps, of which four are four-loculed, the other two being three-loculed. A third three-loculed specimen, now decayed, was figured by Gardner (1883, pl. ix, figs. 5, 6). The other specimens figured by Gardner as *Callitris Ettingshauseni* have also disappeared. V. 15120, now much decayed, was figured as *Callitris curta* by Gardner (1883, pl. ix, figs. 7, 8). A mistake occurs in the explanation of Gardner's plate, as figs. 2 and 3 are both said to be basal views of a " cone " represented in fig. 1. Fig. 2 shows a damaged base such as is indicated in fig. 1, but fig. 3 shows the base of a perfect specimen. They cannot, therefore, both be basal views of the same specimen, and it is probable that fig. 3 represents a basal view of that depicted in fig. 4.

Affinities.—A superficial resemblance to the cones of *Callitris* no doubt accounts for Gardner's reference of the specimens to that genus (1883, p. 22). But the surface of these endocarps is unlike that of a coniferous cone, and any such relationship is prohibited by the internal structure of the fruits and the anatomy of the seeds.

In seeking for the true affinities the most marked peculiarity which has to be taken into account is the germination valve. The occurrence of a valve of this type narrows the search, so far as we have been able to discover, to the families Burseraceae, Humiriaceae, Nyssaceae, Anacardiaceae, and Cornaceae.

The possibility of relationship to Burseraceae can at once be excluded, for in this family the character of the carpel wall is quite different and there are no glandular cavities; also, unlike the fossil, there is a median canal and the placentas are axile, situated about one-third the length of the carpel from the apex; the raphe is ventral, the chalaza is large and conspicuous on the ventral face of the seed, whilst the testa and tegmen have a different structure.

The Humiriaceae must be excluded because of their ventral raphe.

The Nyssaceae, although in many respects resembling the fossil, have the germination valves above the middle of the endocarp, whereas in the fossils now described they occupy more than half the length; the Nyssaceae, again, have a ventral raphe and the cells of the testa are aligned in longitudinal rows, while those of the tegmen are transversely aligned. Hence neither in their seeds nor endocarps do the fossils really resemble the Nyssaceae.

The Anacardiaceae belonging to the section Spondieae somewhat resemble the fossil, but the endocarps have no apical hollow, or globular secreting cavities; they germinate by the extrusion of relatively short, rounded, or oval plugs, not by elongate valves; whilst the chalaza is a large conspicuously-rimmed scar on the narrow dorsal margin of the seed, not small and terminal as in the fossil.

In the Cornaceae, on the contrary, all the characters of the fossil occur, except the number of locules. Certain species of *Cornus* have comparable tortuous cells in the carpel wall, and in *Cornus mas* Linn. identical secreting cavities occur. In many species of *Cornus*, including *Cornus mas*, the raphe is dorsal. The testa, which is partly fused with the locule-lining, shows amoeba-shaped cells resembling those in the fossil; within there is a layer of irregular polygonal cells (seen in *D. multilocularis*, the species next described). The tegmen is also comparable in *Cornus* and in the fossil. Moreover, the seed is pendulous, and in certain species of *Cornus* (*C. macrophylla* Wall., *C. controversa* Hems.) there is a deep apical depression from which the funicles pass to the apices of the locules. Although the living genus *Cornus* is a syncarpous fruit with two locules only, there is evidence in the case of other families (Nyssaceae, p. 429, Sparganiaceae Reid & Chandler, 1926, p. 63) that the number of locules may be less in living than in allied ancient genera or species. There seems, therefore, to be no reason why the fossil should not be referred to the Cornaceae although it cannot actually be placed in *Cornus*, or in any living genus. We have named it *Dunstania*, after Dunstan, Archbishop of Canterbury, 960 to 988.

V. 23022 Neotype, figured Pl. XXV, fig. 41. An endocarp, somewhat abraded at the base.
V. 23023 Figured Pl. XXV, figs. 42, 44–47. An endocarp, now fractured to show valve, locule-cast, and seed.
V. 23024 Figured Pl. XXV, fig. 43. An endocarp (figured to show the side).
The above were labelled by Ettingshausen "*Carpolithes* sp. 27." *Bowerbank Coll.*, Sheppey.
V. 15120 Figured Gardner (1883, pl. ix, figs. 7, 8), a fruit now almost completely decayed. *J. S. Gardner Coll.*, Sheppey.
V. 23025 Two three-loculed endocarps. *Bowerbank Coll.*, Sheppey.

Dunstania multilocularis n. sp.

PLATE XXVI, figs. 1–15.

DIAGNOSIS.—Endocarp ovoid, three- to six-loculed, with a large apical depression, funicular canals often obscure; length, 7·5 to 17 mm.; diameter, 8 to 12·5 mm. Seed terete for about two-fifths of its length at the chalazal end; length, 9 to 10 mm.; breadth of flat dorsal face, 2 mm.

HOLOTYPE.—V. 23026.

DESCRIPTION.—*Fruit:* Ovoid, three- to six-loculed with one pendulous seed in each locule. Surface of exocarp obscured by a mass of structureless pyrites; seen in section the exocarp is formed throughout of large, closely-set, sub-globular cells which were probably secreting as they are filled with a black, shining substance; they show a tendency to be arranged in concentric layers.

Endocarp: Ovoid, with a large circular depression at one end (probably the apex); the hollow may be either filled with loose tissue, or with structureless pyrites, or it may be empty (Pl. XXVI, figs, 1, 2, 5, 6); the short canals which, in some specimens, are seen to connect the hollow with the apices of the locules where the placentas are situated are probably the funicular canals (Pl. XXVI, fig. 1). Each locule has a germination valve in its dorsal wall about three-quarters as long as the endocarp; the valves have smoothly finished edges at the top and sides, but below they break away quite irregularly (Pl. XXVI, fig. 7). Along the lateral margins and median lines of the valves are strong vertical bands of fibres which lie within the wall, near the periphery of the endocarp; when the fruit is much abraded these bands may stand out as ribs. The endocarp walls are thick, formed of long tortuous cells which give them a gnarled structure; there are also many large, scattered, ovoid, glandular cavities (resin cavities ?) which are more numerous in this species than in *D. Ettingshauseni;* they are especially abundant towards the locules (Pl. XXVI, figs. 3, 8–10); the cavities have smooth, shining surfaces formed of large, flat, irregular cells (about 0·05 to 0·1 mm. in diameter) with somewhat sinuous walls. The locule-lining is transversely striate, being formed of elongate cells transversely aligned, which appear to interlock by flat T- or Γ-shaped digitations; the longest diameter of these cells, including the digitations, may be as much as 0·1 mm. The whole surface of the locule is frequently obscured by the adhering testa of the seed. Length of endocarp, 7·5 to 17 mm.; breadth, 8 to 12·5 mm.

Seed: Elongate-oval, terete at the chalazal end, flattened dorsally at the hilar end, where it is gradually attenuated into the funicle (Pl. XXVI, figs. 13–15); as a rule, relatively longer, more slender and less markedly triangular in cross-section, than the seed of *D. Ettingshauseni* (p. 459), and with a shorter dorsal flattening under the valve. Anatropous, with hilum and chalaza both terminal ; the hilum is at the apex of the fruit, and the chalaza, marked by a small inconspicuous circular scar from which the tegmen cells radiate, is at the end of the seed opposite to the hilum ; the raphe, which is median on the dorsal face of the seed, is formed of fine fibres which are united into a slightly sinuous stout cord (Pl. XXVI, fig. 15). The testa is often fused with the locule-lining, whether as the result of fossilization or as an original feature we cannot tell. It appears to be formed of two layers, an outer layer, one cell thick, of digitate cells 0·03 to 0·1 mm. in diameter, and an inner layer of amoeba-shaped or polygonal cells of about the same size. The amoeba-shaped cells gradually give place near the raphe to quadrilateral cells, and over its course they are longitudinally aligned. Cells of the tegmen thin-walled and markedly angular in shape, from 0·03 to 0·1 mm. in diameter. Length of seed, 9 to 10 mm. ; breadth, about 2 mm. ; thickness dorsi-ventrally, from 2 to 3·5 mm.

Remarks.—About 180 endocarps besides many fragments and seeds, the majority from Sheppey, but three from Herne Bay. The appearance of the specimens varies greatly with the degree of abrasion that they have suffered (Pl. XXVI, figs. 1, 3). When but slightly worn the surface of the endocarp shows a series of ribs and grooves ; with more wear, the outline of the valves and funicular canals may show (Pl. XXVI, fig. 1), when the specimens may simulate conifer fruits such as *Callitris* (cf. p. 461) or the conspicuous secreting cells may be exposed (Pl. XXVI, fig. 3), giving the appearance of a many-seeded fruit ; still further abrasion may remove the valves more or less completely, or cause the locule-casts to protrude at one or both ends ; whilst destruction carried yet further may remove the dorsal side of the locule-cast so as to expose the seed with its dorsal raphe, or even the tegmen. The detached valves which are sometimes found are readily recognizable (Pl. XXVI, fig. 12).

Affinities.—The relationship of this fruit to *D. Ettingshauseni* is so obvious from its characters as to call for no further comment. The affinities of the genus *Dunstania* have been fully discussed on p. 461.

V. 23026 Holotype, figured Pl. XXVI, figs. 1, 2. An endocarp, showing the lateral valves and apical hollow.

V. 23027 Figured Pl. XXVI, fig. 3. An endocarp, somewhat abraded, so that the secreting cavities are exposed at the surface.

V. 23028 Figured Pl. XXVI, fig. 4. A large endocarp, showing a peculiar lobing of the apical hollow, perhaps due to the state of abrasion. The hollow is filled with pyrites.

V. 23029–30 Figured Pl. XXVI, figs. 5, 6. Two large endocarps. The apical hollow is filled with pyrites in both ; in one (fig. 5) it appears much larger than in the other (fig. 6) probably owing to a different degree of abrasion of the apex.

V. 23031 Figured Pl. XXVI, fig. 8. A six-loculed endocarp, fractured transversely. It shows the locules and glandular cavities. The mode of germination is also indicated by the pyrites which has infiltrated along the incipient fissures delimiting the valves.

V. 23032 Figured Pl. XXVI, figs. 9, 10. A four-loculed endocarp, fractured transversely, to show the locules and glandular cavities.

V. 23033 Figured Pl. XXVI, fig. 11. An endocarp, fractured longitudinally, with two locule-casts showing their lateral angles.

V. 23034 Figured Pl. XXVI, figs. 7, 12–14. An endocarp, fractured longitudinally, showing the locules. A detached valve of the endocarp and a locule-cast and seed are figured.

V. 23035 Figured Pl. XXVI, fig. 15. A seed, showing the raphe.
V. 23036 Ten endocarps in different stages of abrasion. Some show the apical cavity with, and some without, a filling of pyrites; some show the valves; some are so abraded that the secreting cavities in the endocarp wall are exposed at the surface.
V. 23037 Two small endocarps, fractured longitudinally. Both show the apical hollow; in one it is filled with pyrites.
V. 23038 Two large endocarps, fractured longitudinally; the apical hollow in one, the apical canal for the funicle in the other, are now filled with pyrites.
V. 23039 An endocarp, fractured longitudinally. In one locule the locule-lining can be seen, and in the other the testa.
V. 23040 Two four-loculed fruits, with relatively few secreting cavities, fractured transversely.
V. 23041 Half a transversely fractured six-loculed fruit.
V. 23042 Five and a half seeds or locule-casts detached from endocarps.
V. 23043 An endocarp, now fractured. The seeds are unusually well-preserved and show the raphe; in one seed the chalaza can be seen.
V. 23044 130 endocarps and numerous fragments.
All the above are from the Bowerbank Coll., Sheppey.
V. 23045 Twenty-five endocarps. *Reid & Chandler Coll.*, Sheppey.
V. 23046 Three endocarps. *D. J. Jenkins Coll.*, Herne Bay.

Family EPACRIDACEAE

Section *STYPHELIEAE*

Genus LEUCOPOGON R. Br.

1810. Prodr., p. 541.

Leucopogon quadrilocularis n. sp.

PLATE XXVI, figs. 18–20; text-fig. 17 *a* and *b*.

DIAGNOSIS.—Endocarp globular, woody, syncarpous, with four one-seeded locules, and a central axis; seeds pendulous; locules lined by digitate cells; diameter from 4·2 to 4·75 mm. Seed anatropous; length, 2·75 mm.; breadth of dorsal face, 1·6 mm.; dorsi-ventral thickness, 1 mm.

HOLOTYPE.—V. 23047.

DESCRIPTION.—*Endocarp:* Globular, with four slight longitudinal grooves, syncarpous, four-loculed, with one seed in each locule, indehiscent; the locules are placed symmetrically around the axis with their bases farther from it than their apexes, they are roundly-triangular in cross-section (Pl. XXVI, fig. 20), and ovate in outline both in radial and tangential longitudinal sections. Carpel wall, 0·3 mm. thick, formed of two coats; the outer, which constitutes almost the whole thickness, formed throughout of woody parenchyma with the cells radially aligned except near the locule, where they may have a tortuous alignment; towards the periphery the cells become slightly longer; the inner coat, which forms the locule-lining, is one-cell thick and is formed of large interlocking digitate cells (0·03 × 0·1 mm.). The central axis is pierced by a canal (Pl. XXVI, fig. 20). Placentation axile, the seed being pendulous from below the top of the axis (text-fig. 17 *a*). Diameter of specimen figured Pl. XXVI, figs. 18, 19, 4·75 mm.; diameter of specimen figured, Pl. XXVI, fig. 20, 4·2 mm.

Seed: Conforming in shape to the locule, anatropous, with hilum and chalaza at opposite ends, the hilum being represented by a minute apiculation, and the chalaza by the flattening of the seed, raphe not seen; the micropyle, also represented by a minute apiculation, is close to the hilum (text-fig. 17 *b*); testa composed of angular cells (0·025 mm. in diameter), aligned longitudinally from micropyle to chalaza, becoming smaller towards both these organs. Length, 2·75 mm.; breadth, of dorsal face, 1·6 mm.; thickness, 1 mm.

REMARKS.—Seven specimens, all highly pyritized, some of which were fractured both transversely and longitudinally. The structure suggested alliance with the Epacridaceae, and this was later confirmed by the isolation of a perfect seed showing clearly the hilum, chalaza, and micropyle, but not the raphe, and leading by inference,

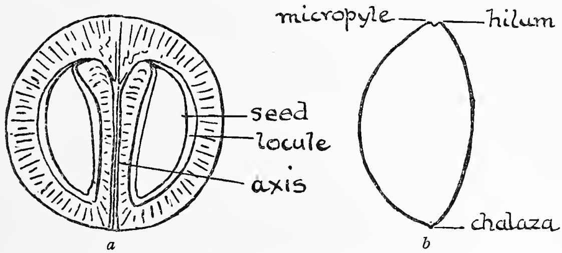


FIG. 17.—*Leucopogon quadrilocularis*. *a*, diagrammatic longitudinal section of fruit, showing placentation; *b*, internal cast of seed (dorsal).

from the position of the hilum and relation of the seed to the axis, also by the divergence of endocarpal cells from the axis, to the knowledge of the axile character of the placentation.

AFFINITIES.—There cannot be any doubt that this species belongs to the Epacridaceae. Every coat of endocarp and testa has its exact counterpart in the fruits and seeds of this family. It belongs to the section Styphelieae (Drude), which has one seed in each locule, and to that part of the section which has indehiscent fruits with endocarps united into a solid many-loculed stone. The only genera in question are *Styphelia* Sol., and certain closely allied genera (sometimes regarded as sub-genera), of which only *Leucopogon* R. Br. and *Lissanthe* Bentham have four locules. It is noteworthy that *Leucopogon* is the only member of the family which ranges beyond Australia and New Zealand into the tropics of Asia, being found in Malaya. The fruits of the fossil are larger than those of any living species of *Leucopogon* known to us, but are of the same size as those of some sections of the genus *Styphelia* Sol., *Cyathodes*, for instance, which is closely allied to *Leucopogon*, only differing in the number of its locules (five or ten).

Under the name *Dulaurensia pulchra* a small fruit belonging to the section Styphelieae of the family Epacridaceae, was described by E. M. Reid from the little florule of St. Tudy, Finistère, collected by the late Henri du Laurens de la Barre; the deposit in which it occurs being of Eocene age, probably Middle Eocene.

V. 23047 Holotype, figured Pl. XXVI, figs. 18, 19. A fruit, now fractured to show the interior.
V. 23048 Figured Pl. XXVI, fig. 20. An endocarp, fractured transversely to show the four locules.
V. 23049 A fruit, worn so that the locule-casts are exposed at the surface. Now broken to show the seeds. One seed shows clearly the adjacent hilum and micropyle and the chalaza at the opposite extremity.
V. 23050 A fruit, worn so that it shows locule-casts. Also a fruit, fractured longitudinally, and fragments of two other fruits.

All the above are Reid & Chandler Coll., Minster, 1929.

V. 23051 A specimen, much encrusted with pyrites, now fractured. It shows evidence for the axile placentation; it also shows clearly the digitate cells of the locule-lining impressed on the locule-cast. *D. J. Jenkins Coll.*, Herne Bay.

Family MYRSINACEAE

Genus ARDISIA Swartz

1788. Prod. Veg. Ind. Occ., iii, p. 48.
1797. Fl. Ind. Occ., i, p. 467.

Ardisia ? eocenica n. sp.

PLATE XXVI, figs. 21–23.

DIAGNOSIS.—Endocarp sub-globular, compressed from base to apex, with a large circular basal depression, and one erect seed; endocarp wall thin, formed of close-set polygonal cells, and on the surface evenly spaced longitudinal strands of fibres; length, 3·4 mm.; diameter, 5·5 mm.

HOLOTYPE.—V. 23052.

DESCRIPTION.—*Endocarp:* Sub-globular, somewhat compressed from base to apex (that accidental compression, before or during fossilization, has somewhat increased the natural compression is shown by the large marginal crumples), one-loculed, one-seeded. Endocarp wall thin (as indicated by the degree of distortion), formed of close-set polygonal cells (0·025 to 0·05 mm. in diameter) variously aligned, with occasionally interbedded, flat, longitudinal strands of delicate fibres. At the base the endocarp is considerably hollowed (naturally, not accidentally) to form a circular depression 3·5 mm. across and 0·5 mm. deep. In the centre of this hollow is a cluster of nodules (Pl. XXVI, fig. 21), and beneath these lies the placenta to which the erect seed is attached. Length of fruit from base of hollow to apex, 3·4 mm.; diameter, 5·5 mm.

Seed: Whether orthotropous, anatropous, or campylotropous, there is no evidence to show. Testa rough, and formed of parenchyma. The seed is considerably shrunken, and, except at the base and its vicinity, is separated from the endocarp by pyrites. Length of shrunken seed, 2 mm.; diameter unknown.

REMARKS.—A locule-cast showing the much worn impressions of small polygonal cells, and traces of longitudinal strands of fibres, was found by ourselves at Minster. A second specimen, now in two pieces, and in a more decayed condition than the preceding, belongs to the Bowerbank Collection. It is a locule-cast with more of the carpel wall preserved, so that the parenchyma and strands of fibres are clearly seen. The specimen is uncrushed, and retains its original sub-globular form; its diameter is 6·5 mm. It was in a jar labelled by Ettingshausen " *Sabal* sp." Owing to its soft and decaying condition, it was not selected as the holotype.

Affinities.—The size, form, cell-structure, and placentation of this one-loculed, one-seeded fruit, the evidence of a thin endocarp, and the character of the testa, all indicate a relationship to the family Myrsinaceae. The only other family which would have fruits with locules of comparable shape (not size) is the Chenopodiaceae, but neither the endocarp nor the seeds of this family are comparable in their structure.

With the Myrsinaceae, the agreement is very close. The endocarps of all the Myrsinaceae we have been able to examine are formed of close-set cells with columnar arrangement as seen in section. In some species this coat is fairly thick and hard; in others, *e.g. Ardisia crenata* Roxb., it is extremely thin and soft, easily distorted. The polygonal cells of which it is formed have a columnar arrangement and their close-set ends line the locule. On the outer surface of this coat in many Myrsinaceae is a system of flat strands of fibres which extend, like lines of longitude, from base to apex. Some of these fibres branch, others do not. The living endocarp which most resembles the fossil is, so far as we have been able to study the family, that of *Ardisia crenata*, a native of Malaya and China. It is the same size, and has a similar, thin, easily distorted endocarp and similar longitudinal fibres, but it is not depressed at the base as is the fossil. *Ardisia mamillata* Hance is, however, similarly depressed, and in the centre of the depression is a cluster of little knobs, exactly as in the fossil, marking the ends of the bundles of nutrient fibres. We think, therefore, that the alliance of the fossil to Myrsinaceae is certain, and that probably it belongs to the genus *Ardisia*.

V. 23052 Holotype, figured Pl. XXVI, figs. 21–23. A locule-cast, with remains of the endocarp, much worn. *Reid & Chandler Coll.*, Minster, 1929.

V. 23053 A much decayed specimen with remains of the endocarp, labelled by Ettingshausen " *Sabal* sp." *Bowerbank Coll.*, Sheppey.

Family SAPOTACEAE

Genus SAPOTICARPUM nov.

Diagnosis.—A form-genus including fruits referable to Sapotaceae which cannot be further distinguished.

Sapoticarpum rotundatum n. sp.

Plate XXVI, figs. 24–30.

1879. *Apeibopsis variabilis* (Bowerbank): Ettingshausen (pars), p. 395.

Diagnosis.—Fruit globular, syncarpous with eight (or more ?) locules; pericarp thick, exocarp formed of parenchyma and fibres with elongate laticiferous vessels; length, 21 mm.; diameter, 23 mm. Seed-cast semicircular, hilar scar long and narrow; length, 15 mm.; breadth (dorsi-ventral), 8 mm.; thickness, 4 mm.

Holotype.—V. 23054.

Description.—*Fruit:* Globular, syncarpous, multilocular, with eight (or possibly more) one-seeded locules. In the fossil state the fruit dehisces loculicidally.

Placentation axile, but exactly where the seed was attached we could not discover, probably all along its ventral face. Pericarp thick ; the thick outer coat is formed of fibres and parenchyma, but embedded among these are elongate, longitudinally aligned structures, simple or branched, yellow and semi-translucent ; which, by comparison with sapotaceous fruits, we take to be laticiferous vessels (Pl. XXVI, fig. 24) ; the inner coat is formed of coarse parenchyma which passes between the locules ; the locule is lined by fine transversely elongate cells. Length of fruit, 21 mm. ; diameter, 23 mm.

Seed : The true external form of the seed has not been seen owing to the decayed condition of the testa, but it can to some extent be inferred from the form of the seed-cast, which is well-preserved (Pl. XXVI, figs. 28–30). Seed-cast compressed laterally, semicircular in outline, with a convex dorsal margin and straight ventral margin, except at the micropylar end (nearest base of fruit), where it is recurved, and the chalazal end (nearest top of fruit), where it is slightly hooked. Seed anatropous, with a long narrow hilar scar occupying (on the cast) the full length of the ventral margin, including the recurved portion ; the raphe passes between the coats of the testa at the chalazal end, and repeatedly branches over the surface of the seed between these two coats, the branches being directed towards the opposite end of the seed ; the micropyle is terminal on the ventral margin. The testa, which is thick and appears to have been woody, shows two coats. The outer coat is thick and formed of many layers of equiaxial polygonal cells which in transverse sections of the seed have a columnar arrangement ; the outer layers, which are more compact than the inner, form a hard smooth finely-punctate surface, the cells of the inner layers, which are sometimes preserved as impressions on the seed-cast covered by the inner coat of the testa, measure 0·03 mm. in diameter. The inner coat of the testa is thin and much rougher than the outer coat. Length of seed-cast, 15 mm. ; dorsi-ventral breadth, 8 mm. ; thickness, 4 mm.

Remarks.—One imperfect fruit, and part of a fruit with a worn seed. The former had broken in half, one half having partly disintegrated before it came into our hands. Fortunately it was possible to photograph it before it finally decayed and fell to pieces (Pl. XXVI, figs. 24, 25). It was clearly multilocular, with one seed in each locule, and the best preserved half showed four seeds. Hence, the fruit must have contained eight locules, or possibly nine. The most perfect seed was represented by a cast, with adhering patches of the testa. On its surface could be seen obscure indications of the branching fibres and clearer impressions of the polygonal cells of the outer coat. The form of the cast is as described above (cf. Pl. XXVI, figs. 28–30), but almost certainly it does not represent the true form of the seed, because in Sapotaceae there is (always ?) a great thickening of the testa at the micropylar end, so that externally the seed may be more or less beaked (not to be confounded with the beak on the seed-cast at the chalazal end, the beak in that case being the cast of the canal by which the raphe enters), but internally the seed-cavity is obliquely truncate; the seed-cast would, therefore, frequently assume the recurved form of the fossil (Pl. XXVI, figs. 28, 29), whilst the seed itself would not.

Affinities.—There can be no doubt that this specimen belongs to the Sapotaceae. Every character proclaims its relationship : the form of the fruit, the fibrous coat with laticiferous vessels, the many-loculed syncarpous fruit with one seed in each locule, the attachment of the seeds, their shape with the long narrow hilar scar, the structure of the testa, and above all the branching fibres of the raphe. It is a matter of greater difficulty to refer the specimen to its place within the family, because we do not know the exact form of the perfect seed. Even so, there are such close resemblances between the seeds of some living genera that it might be most difficult, or perhaps impossible, to determine the closest relations. We have placed the specimen in the form-genus *Sapoticarpum*, under the name *S. rotundatum*.

V. 23054 Holotype, figured Pl. XXVI, figs. 24–30. Part of a fruit with seeds. In a jar together with *Cupanoides* and *Lagenoidea*, labelled by Ettingshausen "*Apeibopsis variabilis.*" The fruit is rapidly disintegrating. *Bowerbank Coll.*, Sheppey.

V. 23055 Part of a fruit, with an abraded seed on which patches of the outer coat of the testa can still be seen. *Bowerbank Coll.*, Sheppey.

Sapoticarpum latum n. sp.

Plate XXVI, figs. 31–38.

Diagnosis.—Fruit obovate, five-loculed, seeds basi-fixed ; exocarp thick and fibrous ; length, 15 to 18 mm. ; diameter, 18 to 21 mm. Seed broadly obovate, laterally compressed, slightly beaked at the micropylar end, hilar scar narrow and extending the full length of the seed ; length, 12 mm. ; dorsi-ventral breadth, 8 mm. Seed-cast slightly convex on the ventral margin.

Holotype.—V. 23056.

Description.—*Fruit:* Obovate, syncarpous, five-loculed, each locule one-seeded, seeds basi-fixed. Exocarp thick and fibrous, the fibres running longitudinally. Endocarp formed of many layers of fibres which both externally and internally are aligned obliquely ; in section the endocarp wall appears columnar. Length of fruit, 15 to 18 mm. ; diameter, 18 to 21 mm. Length of locule, 12 mm. ; breadth, 8·5 to 9 mm. ; thickness, 4 to 6·5 mm.

Seed: Broadly obovate, laterally compressed ; pointed and slightly beaked at the micropylar end, rounded at the opposite end (the seed-cast is more or less convex along the ventral margin) ; anatropous, the hilar scar long and narrow, extending the whole length of the ventral margin (Pl. XXVI, figs. 32, 33, 38), and the raphe entering between the coats of the testa at the chalazal end, from which point it branches repeatedly over the surface of the seed towards the opposite end (Pl. XXVI, fig. 38). The testa is smooth, shining, and finely pitted externally, the pittings being produced by the close-set polygonal cells of the epidermis, 0·016 mm. in diameter ; the coat next within is thick, formed of parenchymatous cells, with a columnar arrangement, measuring from 0·025 to 0·03 mm. in diameter ; this coat thickens towards the micropyle. The inner coat of the testa is thin. Length of seed, 12 mm. ; dorsi-ventral breadth, 8 mm.

Remarks.—Three fruits ; two show the exocarp in a fairly good state of preservation. One has broken longitudinally, probably as the result of decay, for it has split through two locules in accordance with the natural mode of dehiscence. This specimen shows clearly the broadly oval form of the seeds of which external impressions have been preserved on the locule-casts (Pl. XXVI, figs. 32, 33). In the third specimen the pericarp has been abraded from the dorsal walls of the locules and to a very great extent between them so that the hard locule-casts protrude (Pl. XXVI, figs. 34–36). Further, some of the locule-casts are broken or worn on their dorsal surfaces so that the seed-casts, with the testa in section around them, are exposed. The specimen was fractured in order to ascertain whether it belonged to the same species as the two other fruits. The fracture proved conclusively that the seeds had the same form and structure.

Affinities.—The form and structure of this fruit and of its seeds leave no doubt that it belongs to the Sapotaceae. Comparison with living species shows that similar long narrow hilar scars are found in many genera of this family. Among these, the two which show most resemblance to the fossil in the form of the seed are *Chrysophyllum* and *Sideroxylon*. But whereas the seeds of *Chrysophyllum* are relatively broad dorsi-ventrally and not more compressed laterally than those of the fossil, the seeds of *Sideroxylon* are narrower dorsi-ventrally and more compressed laterally than the fossil seeds. Nevertheless, since the relationship is inconclusive, we have thought it better to refer the species to the form-genus *Sapoticarpum* under the name *Sapoticarpum latum*.

The fruit and seeds of *S. latum* both differ from those of *S. rotundatum*. The fruit of *S. latum* is obovoid, five-loculed, without laticiferous vessels (so far as the evidence shows) ; whilst the fruit of *S. rotundatum* is globular, eight-loculed, with laticiferous vessels. Again, the seed-casts of *S. latum* are broadly ovate, more or less convex on the ventral margin ; whilst those of *S. rotundatum* are semicircular, straight, or slightly concave on the central margin. The two species must therefore be regarded as distinct.

V. 23056 Holotype, figured Pl. XXVI, figs. 31–33. A fruit, fractured longitudinally, showing the external impressions of seeds lying within the locules.
V. 23057 Figured Pl. XXVI, figs. 34–38. An abraded fruit showing five locule-casts and portions of seeds or seed-casts.
V. 23058 A fruit somewhat abraded so that the dorsal margins of the locule-casts are partially exposed.
All are from the Bowerbank Coll., Sheppey.

Sapoticarpum dubium n. sp.

Plate XXVI, figs. 39–41.

Diagnosis.—Fruit sub-ovoid or sub-globular, five-loculed ; pericarp formed of cells longitudinally aligned, measuring about 0·1 × 0·05 mm. ; length from 13 to 17 mm. ; diameter from 14 to 17 mm. Seed sub-oval, laterally compressed.

Holotype.—V. 23059.

Description.—*Fruit :* Sub-ovoid, or sub-globular, dehiscing loculicidally, five-loculed, each locule one-seeded, placentation axile. Pericarp formed of large rounded-oblong cells (now filled with glistening pyrites) which frequently measure 0·1 by 0·05 mm. in diameter, and are aligned longitudinally. Locule-lining formed of elongate cells obliquely aligned which give rise to oblique striations. Length of one fruit, 13 mm.; diameter, 14 mm. Length of the other fruit, 17 mm.; diameter, 17 mm.

Seed: Sub-oval, laterally compressed, dorsal margin almost semicircular, ventral margin not completely seen, but the evidence suggests that it was straight or very slightly convex. The epidermal cells of the testa are polygonal, from 0·016 to 0·025 mm. in diameter, and form a smooth shining surface; the coat within, columnar in transverse sections of the seed, is formed of rather larger polygonal cells.

Remarks and Affinities.—Two fruits, both of which had broken loculicidally. In the one which has been taken as the holotype the seeds are visible, but all are broken; a perfect seed or seed-cast has not been seen. The other fruit shows the locule-casts. The structure of this loculicidal fruit and the shape and structure of the seeds, in so far as these are known, point to the species belonging to the Sapotaceae. It is chiefly distinguished by the cellular structure of its pericarp from the two species previously described, in which the pericarp is fibrous. We have referred it to the form-genus *Sapoticarpum* under the name *S. dubium*.

V. 23059 Holotype, figured Pl. XXVI, figs. 39–41. A fruit, fractured loculicidally, showing the remains of seeds.
V. 23060 A fruit, fractured loculicidally.
Both are from the Bowerbank Coll., Sheppey.

Genus SAPOTISPERMUM nov.

Diagnosis.—A form-genus including seeds referable to the Sapotaceae, but which cannot be more definitely determined.

Sapotispermum sheppeyense n. sp.

Plate XXVII, figs. 1, 2.

1879. *Podogonium Sheppyense* Ettingshausen (pars), p. 396.
1879. *Bauhinia primigenia* Ettingshausen (pars), p. 396.

Diagnosis.—Seed hard, gibbous, with a long straight ventral margin, laterally compressed; hilar scar narrow, pointed at the chalazal end and rounded at the micropylar end, surface-cells of testa polygonal, measuring 0·015 to 0·016 mm. in diameter; length, 12 mm.; breadth (incomplete), 9·3 mm. Seed-cast ovate (not gibbous); length, 9 to 10 mm.; dorsi-ventral breadth, 6 to 7 mm.; thickness, 3 to 4 mm.

Holotype.—V. 23061.

Description.—*Seed:* Gibbous, with a straight, ventral margin and convex dorsal margin (Pl. XXVII, fig. 1), laterally compressed. Hilar scar narrow, pointed at the chalazal end and rounded at the opposite (micropylar) end, 11 mm. long, extending almost the whole length of the ventral margin. Surface smooth and shining, formed of a layer of polygonal cells 0·015 to 0·016 mm. in diameter. Beneath this the testa is thick, hard and woody, formed throughout of polygonal cells, except the innermost layer, in which the cells are elongate and aligned longitudinally. The testa is greatly thickened over the hilum and micropyle, more especially over the latter, so that the ventral margin of the seed-cast differs from the ventral margin of the seed in shape, being more convex, especially at the micropylar end; the seed-cast is therefore ovate rather than gibbous in outline. The raphe passes between the coats of the testa at the chalazal end and immediately branches over the surface of the inner coat, the branches repeatedly bifurcating in the direction of the micropyle (Pl. XXVII, figs. 1, 2). Length of seed, 12 mm.; dorsi-ventral breadth (incomplete), 9·3 mm. Length of seed-cast, 9 to 10 mm.; dorsi-ventral breadth, 6 to 7 mm.; thickness, 3 to 4 mm. Thickness of testa at the middle of the hilar scar, 2·5 mm.

REMARKS.—Four specimens and three doubtful ones from Sheppey. Also three specimens collected by ourselves at Minster, which should almost certainly be referred to this species.

The seed taken as the holotype has part of the testa and the whole of the hilar scar preserved along the ventral margin. The other specimens are merely internal casts of seeds. One of them was in a jar (together with other seeds) labelled by Ettingshausen "*Bauhinia primigenia* sp. n." Two were in another jar, labelled "*Podogonium Sheppyense* sp. n." These two were associated with three other broken and worn seeds which are too decayed for determination, but which by their flattened shape and the apparent remains of hilar scars must have belonged to the Sapotaceae.

AFFINITIES.—There cannot be any doubt that these are the seeds of a species referable to the family Sapotaceae. The form, the character of the hilum, and the arrangement of the vascular strands within the testa all point clearly to this relationship. We have found seeds with similar contours and with similar long hilar scars in a number of genera; for example, *Chrysophyllum* and *Sideroxylon.*

V. 23061 Holotype, figured Pl. XXVII, fig. 1. A seed, internal cast, with remains of the testa adhering along the ventral margin, showing the hilum. *Bowerbank Coll.*, Sheppey.

V. 23062 Figured Pl. XXVII, fig. 2. An internal cast of a seed showing how the fibres branch over the inner layer of the testa. The jar containing this specimen was labelled by Ettingshausen "*Podogonium Sheppyense* sp. nov." *Bowerbank Coll.*, Sheppey.

V. 23063 A second internal seed-cast similarly labelled. *Bowerbank Coll.*, Sheppey.

V. 23064 A seed-cast labelled by Ettingshausen "*Bauhinia primigenia* sp. n." *Bowerbank Coll.*, Sheppey.

V. 23065 Three seed-casts. *Reid & Chandler Coll.*, Minster.

V. 23066 Three worn and broken seed-casts with remains of the testa. They were in the same jar as V. 23062–63 above. They probably belong to the Sapotaceae, and may even belong to this species, but are too decayed for determination. *Bowerbank Coll.*, Sheppey.

Sapotispermum sp. 2

PLATE XXVII, figs. 3, 4.

DESCRIPTION.—*Seed:* Represented by an internal cast only, elongate-oval, narrowed at both ends, somewhat compressed, with a long oval hilar scar broader at the micropylar than at the chalazal end and recurved at the micropylar end. The surface of the cast shows obscure impressions of large vascular strands diverging from the chalaza along the length of the seed; the strands are thick and straight, they scarcely diminish in thickness throughout their length, and can be traced almost to the micropylar end of the seed-cast ; they appear to branch but sparingly. Length of cast, 10 mm. ; breadth (dorsi-ventral), 5 mm. ; thickness, 3·5 mm.

Remarks and Affinities.—One seed-cast, perfect as regards its form, but somewhat abraded as regards its surface, so that no cell-structure can be seen. The direction of the fibres shows clearly which end is micropyle and which chalaza.

In its shape the seed is unlike any other sapotaceous seeds here described ; it is smaller and more slender in outline, although it is fairly thick in proportion to its width. The fibrous bands in this species are straighter, longer, less branched and stouter than in those previously described.

V. 23067 Figured Pl. XXVII, figs. 3, 4. An internal cast of a seed, somewhat abraded. *Bowerbank Coll.*, Sheppey.

Family SYMPLOCACEAE

Genus SYMPLOCOS Jacquin

1760. Enum. Pl. Carib., p. 5.

Symplocos trilocularis n. sp.

Plate XXVII, figs. 5–9.

Diagnosis.—Endocarp ovoid, three-loculed, with many irregular cavities in its wall ; locules sub-cylindric, constricted above the middle ; length, 7·25 mm. ; diameter, 5·25 mm.

Holotype.—V. 23068.

Description.—*Endocarp :* Ovoid, three-loculed, the locules being sub-cylindric, but narrowing slightly at the base, one locule more developed than the other two. A locule which has been sectioned longitudinally shows a rather sharp constriction a little above the middle, on the side towards the periphery of the endocarp (Pl. XXVII, figs. 7, 8). At the apex of the endocarp there are three circular depressions which mark the external openings of the three locules (Pl. XXVII, fig. 6). The external surface of the endocarp is too worn and decayed for the cells to be visible. The walls are thick, formed largely of coarse parenchyma, the cells being about 0·05 mm. in diameter, but within the thickness of the walls are many irregular scattered cavities with no clearly defined boundaries. These cavities are now filled with pyrites. Near the locules the parenchyma is more compacted than elsewhere, and immediately around each locule the cells are aligned radially, especially towards the apex, so as to form a thin columnar coat. The locule-lining is formed of small cells. The locules appear to be single-seeded. Length of endocarp, 7·25 mm. ; diameter, 5·5 mm.

Seed : Sub-cylindric, narrowed slightly towards the chalaza ; ? anatropous, the chalaza being at the end of the seed adjacent to the base of the fruit. Testa formed of elongate, parallel-sided, slightly curved cells, faceted at their ends, about five times as long as they are broad, and with a general longitudinal alignment. Length of seed, 5·75 mm. ; maximum diameter, 1·5 mm.

sided cells, averaging 0·4 mm. long × 0·05 mm. broad, with either obliquely faceted or tapering ends and much thickened lateral walls, so that the seed appears sinuously striate in a longitudinal direction. The inner coat, which is also shining, is represented only by the impression of its large angular cells, averaging from 0·05 to 0·1 mm. in diameter. Over the middle of the seed the cells of the inner coat tend to be aligned transversely. Length of seed measured along the line of curvature, 6 mm.; diameter, 1·3 mm.

REMARKS.—One imperfect endocarp which had been broken longitudinally, thus exposing one perfect and one broken seed within their respective locules. Part of one side of the endocarp is missing, but the relative proportions of the remaining fragments and of that which is lost suggest that there probably was originally a third locule, but no trace of it can now be seen. After photographing the specimen, the seed was removed from the locule and part of the outer coat of the testa was carefully detached so that the scar of the micropyle and the impression of the inner coat of the testa were exposed on the seed-cast.

AFFINITIES.—The crooked sub-cylindric locules and seeds at first suggested a relationship with *Guettarda speciosa* Linn. of the family Rubiaceae. But microscopic study of the endocarp and testa showed that the resemblance was merely superficial. We therefore proposed to search among genera having fruits with cylindric locules, on the supposition that the crooked form of the locules and seeds was due to deformity. *Symplocos* happened to be the first genus studied and, at once, the absolute identity of the seed-coats in the fossil with those of two or three living species examined, showed that it was to this genus that the fossil must be referred. So far as limited material has enabled us to study them, the carpel walls in different species of *Symplocos* vary considerably both in compactness and hardness, and also in the size and arrangement of the parenchymatous cells. The structure of the carpel wall seen in this fossil species is of a type common in the genus. Nevertheless there is a difficulty, because we have not seen the most arresting feature of the fossil, the curved locules, in any living *Symplocos*. At the same time the very small number of endocarps whose structure we have been able to study at all, and the far smaller number in which we have been able to trace the complete form of the locule, does not permit us to state that it can never occur. The sub-section *Palura*, which is widely represented in the south-east of Asia and Malaya, has curved seeds but, so far as we have been able to examine species belonging to it, the curvature is more uniform, not a sharp crook as in the fossil. Since the structure is otherwise identical with what occurs in the genus, this difference between an angular and a smooth curvature of the locule does not appear sufficient to debar the fossil from inclusion in the living genus.

This species is distinguished from the two previously described by its crooked locules and seeds and also by the presence of oval glandular cells. In both the other species the locules are constricted but not crooked. In size it approximates most nearly, as at present preserved, to *Symplocos trilocularis*, although it may originally have been larger than that species, prior to abrasion. It differs from *S. trilocularis*, however, not only in the characteristics named above, but also in the finer parenchyma of the carpel wall. We, therefore, regard it as a distinct species, which we name *Symplocos curvata*.

V. 23070 Holotype, figured Pl. XXVII, figs. 12–14. A broken endocarp, superficially abraded and longitudinally sectioned. *Bowerbank Coll.*, Sheppey.

Family APOCYNACEAE

Genus OCHROSOIDEA nov.

DIAGNOSIS.—Differing from *Ochrosia* in sometimes having jointed fruits, in the longer and more vermiform cells of its pericarp, and in its lateral instead of terminal placentas, not produced into false dissepiments.

GENOTYPE.—*O. sheppeyensis* n. sp.

Ochrosoidea sheppeyensis n. sp.

PLATE XXVII, figs. 15–29.

1879. *Apocynophyllum Sheppyense* Ettingshausen, p. 394.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 23071.

DESCRIPTION.—*Fruit:* A woody capsule, segmented or unsegmented, with one seed in each segment ; segments of variable form, obovoid, sub-globose, fusiform or, rarely, urceolate ; dehiscing dorsi-ventrally into two symmetric, boat-shaped valves (Pl. XXVII, figs. 15–22), the locule being oval in outline and lenticular in section. Each valve is encircled by a strong marginal band of fibres (Pl. XXVII, figs. 15, 16), which is thickened at the middle of one margin over the placenta. The pericarp is formed of two coats besides the locule-lining. The outer coat is thick and formed of large inflated vermiform cells, from two to six times as long as they are broad, aligned transversely as seen in longitudinal sections of the fruit (Pl. XXVII, fig. 28). In transverse sections of the fruit they show a sinuous arrangement (Pl. XXVII, fig. 29). This outer coat is traversed by fibres especially towards the periphery. The inner coat of the pericarp is formed of many concentric layers of transversely aligned fibres, which have their origin in the encircling fibrous band already described. As a result of fossilization and decay this coat tends to separate into two concentric shells, the outer shell remaining fused to the valves, and the inner shell being fused with the locule-cast. The locule-lining (very rarely seen on account of this adhering cover of fibres) is formed of small polygonal cells, 0·03 mm. in diameter, concave on their inner faces (those towards the locule) ; these cells become more oblong towards the margin and are aligned parallel to it. The locule-cast is lenticular both in transverse and longitudinal section, and sub-quadrangular in outline with a lateral emargination where the placenta protrudes into the locule. Its true form is rarely seen, being concealed by the adhering fibres of the pericarp. The cast figured Pl. XXVII, fig. 23, is covered by these fibres, and at both ends the apparent length of the locule-cast is thereby greatly increased. Such casts, which sided cells, averaging 0·4 mm. long × 0·05 mm. broad, with either obliquely faceted or tapering ends and much thickened lateral walls, so that the seed appears sinuously striate in a longitudinal direction. The inner coat, which is also shining, is represented only by the impression of its large angular cells, averaging from 0·05 to 0·1 mm. in diameter. Over the middle of the seed the cells of the inner coat tend to be aligned transversely. Length of seed measured along the line of curvature, 6 mm.; diameter, 1·3 mm.

Remarks.—One imperfect endocarp which had been broken longitudinally, thus exposing one perfect and one broken seed within their respective locules. Part of one side of the endocarp is missing, but the relative proportions of the remaining fragments and of that which is lost suggest that there probably was originally a third locule, but no trace of it can now be seen. After photographing the specimen, the seed was removed from the locule and part of the outer coat of the testa was carefully detached so that the scar of the micropyle and the impression of the inner coat of the testa were exposed on the seed-cast.

Affinities.—The crooked sub-cylindric locules and seeds at first suggested a relationship with *Guettarda speciosa* Linn. of the family Rubiaceae. But microscopic study of the endocarp and testa showed that the resemblance was merely superficial. We therefore proposed to search among genera having fruits with cylindric locules, on the supposition that the crooked form of the locules and seeds was due to deformity. *Symplocos* happened to be the first genus studied and, at once, the absolute identity of the seed-coats in the fossil with those of two or three living species examined, showed that it was to this genus that the fossil must be referred. So far as limited material has enabled us to study them, the carpel walls in different species of *Symplocos* vary considerably both in compactness and hardness, and also in the size and arrangement of the parenchymatous cells. The structure of the carpel wall seen in this fossil species is of a type common in the genus. Nevertheless there is a difficulty, because we have not seen the most arresting feature of the fossil, the curved locules, in any living *Symplocos*. At the same time the very small number of endocarps whose structure we have been able to study at all, and the far smaller number in which we have been able to trace the complete form of the locule, does not permit us to state that it can never occur. The sub-section *Palura*, which is widely represented in the south-east of Asia and Malaya, has curved seeds but, so far as we have been able to examine species belonging to it, the curvature is more uniform, not a sharp crook as in the fossil. Since the structure is otherwise identical with what occurs in the genus, this difference between an angular and a smooth curvature of the locule does not appear sufficient to debar the fossil from inclusion in the living genus.

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V. 23070 Holotype, figured Pl. XXVII, figs. 12–14. A broken endocarp, superficially abraded and longitudinally sectioned. *Bowerbank Coll.*, Sheppey.

Family APOCYNACEAE

Genus OCHROSOIDEA nov.

Diagnosis.—Differing from *Ochrosia* in sometimes having jointed fruits, in the longer and more vermiform cells of its pericarp, and in its lateral instead of terminal placentas, not produced into false dissepiments.

Genotype.—*O. sheppeyensis* n. sp.

Ochrosoidea sheppeyensis n. sp.

Plate XXVII, figs. 15–29.

1879. *Apocynophyllum Sheppyense* Ettingshausen, p. 394.

Diagnosis.—That of the genus.

Holotype.—V. 23071.

Description.—*Fruit:* A woody capsule, segmented or unsegmented, with one seed in each segment; segments of variable form, obovoid, sub-globose, fusiform or, rarely, urceolate; dehiscing dorsi-ventrally into two symmetric, boat-shaped valves (Pl. XXVII, figs. 15–22), the locule being oval in outline and lenticular in section. Each valve is encircled by a strong marginal band of fibres (Pl. XXVII, figs. 15, 16), which is thickened at the middle of one margin over the placenta. The pericarp is formed of two coats besides the locule-lining. The outer coat is thick and formed of large inflated vermiform cells, from two to six times as long as they are broad, aligned transversely as seen in longitudinal sections of the fruit (Pl. XXVII, fig. 28). In transverse sections of the fruit they show a sinuous arrangement (Pl. XXVII, fig. 29). This outer coat is traversed by fibres especially towards the periphery. The inner coat of the pericarp is formed of many concentric layers of transversely aligned fibres, which have their origin in the encircling fibrous band already described. As a result of fossilization and decay this coat tends to separate into two concentric shells, the outer shell remaining fused to the valves, and the inner shell being fused with the locule-cast. The locule-lining (very rarely seen on account of this adhering cover of fibres) is formed of small polygonal cells, 0·03 mm. in diameter, concave on their inner faces (those towards the locule); these cells become more oblong towards the margin and are aligned parallel to it. The locule-cast is lenticular both in transverse and longitudinal section, and sub-quadrangular in outline with a lateral emargination where the placenta protrudes into the locule. Its true form is rarely seen, being concealed by the adhering fibres of the pericarp. The cast figured Pl. XXVII, fig. 23, is covered by these fibres, and at both ends the apparent length of the locule-cast is thereby greatly increased. Such casts, which are the entities which fall free when the fruit is broken or when it decays, we have named " pseudo-locule-casts." Length of fruit varying from 9 to 20 mm.; breadth varying from 7 to 13 mm. Average length, 16 mm.; average breadth, 12 mm.

Seed: Conforming in shape to the locule, with a large concavity on the ventral margin near the placenta, which gives it a beaked form at this end, *i.e.* the end nearest the style (Pl. XXVII, fig. 26). The hilum has not been seen, but probably lies in this concavity, adjacent to the placenta. The testa is formed of two coats. The outer coat, which is about 0·1 mm. thick, is formed of irregularly angular cells, 0·016 to 0·025 mm. in diameter, which have a columnar arrangement (Pl. XXVII, fig. 27). The inner coat is loose-textured, formed of several layers of large, thin-walled cells with obscure outlines. Very frequently the walls have either decayed or become pyritized so as to merge with the matrix; the coats thus appear intermittent, and are very difficult to trace. The inner coat appears to be thickest around the margins of the seeds as though it formed an encircling wing. The exact form of the seed-body has never been seen. Length of seed, 10 mm.; breadth, about 6 mm.

REMARKS.—About 135 specimens, which include about ninety fruits and more than forty detached valves; there are also several seeds, and numerous fragments of fruits or valves.

Almost invariably the specimens, as preserved, consist of one carpel only, but two have two carpels or segments (Pl. XXVII, figs. 18, 19), and many of the fossils are truncated at one end, as if a second segment had broken away (Pl. XXVII, fig. 20). The locule-casts usually consist entirely of pyrites, but occasionally the pyrites encloses remains of a seed (Pl. XXVII, figs. 26, 27). Owing to the delicate character of the testa, the seeds are difficult to isolate, and it is impossible to trace their outlines continuously in a sectioned locule-cast, as at intervals the coats have decayed and are replaced by the pyrites of the matrix. The difficulty of studying the seeds is further enhanced by the frequent presence of carbonaceous galls within the testa which completely or partially obscure their true structure (Pl. XXVII, fig. 27). Similar galls have been observed in other fossil fruits from the London Clay (cf. *Cantitilia polysperma*, p. 396, Pl. XX, fig. 10).

AFFINITIES.—The relationship of the fossil is clearly with *Ochrosia* Juss. of the family Apocynaceae. In form, size, mode of dehiscence, and character of the valves it closely resembles this genus, but it differs in several important respects. Thus we have not seen jointed fruits in *Ochrosia*, although a specimen of *O. elliptica* Labell. in Kew Herbarium showed two seeds one above the other with a very slight constriction of the carpel between them; and it is to be noted that jointed fruits occur in the family (*Condylocarpon* Desf. for instance, although in other characters it does not resemble the fossil). Again, the cells which form the outer coat of the pericarp are longer and more vermiform in the fossil than in *Ochrosia*, and the scattered bundles of fibres are fewer. The seeds of the fossil are attached marginally to a lateral placenta; those of *Ochrosia* to a terminal placenta which is produced into a false dissepiment between the valves. In view of these differences we have thought it inadvisable to refer the fossil to the living genus *Ochrosia*, but in order to indicate the obvious relationship we have named it *Ochrosoidea sheppeyensis*.

The living *Ochrosia* is a genus of trees inhabiting the Malay Peninsula and Islands, Australia, the Mascarene Islands, and some of the islands of the Pacific Ocean. It is a littoral plant, and its endocarps are common among the drift fruits carried by ocean currents (Guppy, 1890, pp. 17, 24, 32). The specimens of *Ochrosoidea* belonging to the Bowerbank Collection were labelled by Ettingshausen "*Apocynophyllum Sheppyense*," but the name was published without figures or descriptions (1879, p. 395). *Apocynophyllum* is a form-genus proposed by Unger (1850, p. 433), and based entirely on leaf characters. It includes almost certainly several true genera, and possibly representatives of several families. Ettingshausen, in his list of London Clay fruits, extended the use of the form name to include apocynaceous fruits which he believed might be related to some of the previously determined leaves. But in doing so he brought no shred of evidence to support his contention. Whatever justification there might be for such a course, were it only ordinal, not generic and specific, characters that were in question, there can be none in the present case, for *Ochrosoidea sheppeyensis* is far too well characterized generically, and probably specifically also, to be included merely in a form-genus. At the same time the credit of recognizing the systematic position of these fossil fruits is due to him, and we have, therefore, made use of the specific name given in his list of *nomina nuda*.

V. 23071 Holotype, figured Pl. XXVII, figs. 15, 16. A fruit, showing the two valves.
V. 23072 Figured Pl. XXVII, fig. 17. A valve of a fruit, figured to show the smooth external surface.
V. 23073 Figured Pl. XXVII, figs. 18, 24. A two-loculed fruit, the locules separated by a slight constriction.
V. 23074 Figured Pl. XXVII, fig. 19. A jointed two-loculed fruit.
V. 23075 Figured Pl. XXVII, fig. 20. A small specimen, truncate at one end, suggesting that it was formerly part of a jointed two- or more-loculed fruit.
V. 23076 Figured Pl. XXVII, figs. 21–23. A fruit which has dehisced, showing two valves (figs. 21, 22) and the pseudo-locule-cast (fig. 23). The pseudo-locule-cast is fractured and shows the remains of the seed within.
V. 23077 Figured Pl. XXVII, fig. 25. A fruit, fractured transversely to show the relationship of the locule and valves.
V. 23078 Figured Pl. XXVII, fig. 26. A seed lying in a pseudo-locule-cast. The seed shows the beak-like hilar extremity and the emargination which marks the actual position of the hilum.
V. 23079 Figured Pl. XXVII, fig. 27. A pseudo-locule-cast, fractured longitudinally, showing the seed in section, its outline obscured by a gall which occupies part of the seed-cavity.
V. 23080 Figured Pl. XXVII, figs. 28, 29. A fruit fractured to show the structure of the carpel wall.
V. 23081 A specimen with part of the carpellary valves preserved. The pyrites cast (pseudo-locule-cast) of the space between the two valves is broken and shows the true locule-lining and the true locule-cast within it. The true locule-cast is also broken and shows part of the seed.
V. 23082 A pseudo-locule-cast, broken transversely. It shows a well-developed gall which obscures the true seed.
V. 23083 A fractured pseudo-locule-cast, showing part of a seed.
V. 23084 Eighty fruits, forty valves, and numerous fragments. Some of these were originally labelled by Ettingshausen "*Apocynophyllum Sheppyense*."

All the above are from the Bowerbank Coll., Sheppey.

V. 23085 Four fruits and some fragments. *Reid & Chandler Coll.*, Sheppey.

Genus OCHROSELLA nov.

DIAGNOSIS.—Fruit ovoid, slightly compressed laterally, one-seeded, dehiscing into two equal valves, possibly with a false dissepiment in the locule; length, 4·6 mm.; greatest diameter, 3·8 mm.; least diameter, 3 mm.

GENOTYPE.—*O. ovalis* n. sp.

Ochrosella ovalis n. sp.

PLATE XXVII, figs. 30, 31.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 23086.

DESCRIPTION.—*Fruit:* Small, ovoid, slightly compressed laterally, one-celled, one-seeded; dehiscing into two equal valves along a plane containing the two longer axes; the placenta probably marginal; locule-cast (and therefore locule) lentiform. As preserved, the external coat of the pericarp is formed of coarse, loose, or cavernous parenchyma, thick over the convex lateral surfaces, within which is a coat of parenchyma with cells transversely aligned, so that where it is exposed the surface appears transversely striate; but the cells also appear to diverge from one end where the locule-cast is narrowed to a point, probably indicating that here was the style. Within these coats is a smooth surface (seen only in a few patches) which bears the impression of flat criss-cross layers of fibres. There is reason to think that this may be part of a false dissepiment formed by the placenta. Greatest length of the fruit, 4·6 mm.; greatest diameter, 3·8 mm.; least diameter, 3 mm.

Seed: Oval in transverse section (seen in section Pl. XXVII, fig. 31). Testa pitted.

REMARKS.—The external surface of the two specimens is completely featureless; they look like rolled pebbles. On fracturing one in the hope of discovering its true nature, one valve was detached. The remaining valve and adherent locule-cast (Pl. XXVII, fig. 30) were then fractured transversely in order to discover whether there were one or two locules. The result showed that there was only one. The second specimen was imperfect, being broken transversely so that the locule-cast and seed-cast were seen in section between the two valves (Pl. XXVII, fig. 31).

AFFINITIES.—In studying these specimens we first considered whether they could represent lenticular seeds such as those of the Cucurbitaceae; but we found that none was in any degree comparable. Moreover, the transverse alignment of the cells around the locule, and the criss-cross layers of fibres of the supposed dissepiment are far more suggestive of carpellary coats than of seed-coats. We therefore examined all the one-loculed one-seeded fruits that we could find. We found no laterally compressed fruits with the cells surrounding the locule transversely aligned except in the Apocynaceae. It seems, therefore, almost certain that the fossil belongs to this family, with which it has many features in common. In *Ochrosia*, for instance, the fruits are similar in shape, although they are much larger; the outer portion of the pericarp is formed of similar cavernous parenchyma, the inner layers being formed of transversely aligned fibres, not cells as in the fossil; the placenta in *Ochrosia* is expanded to form a platiform dissepiment which lies symmetrically across the locule when two seeds are developed, but may be displaced against one lateral wall when only one seed is present; this dissepiment is formed of criss-cross layers of fibres corresponding in appearance with the criss-cross layers seen in the fossil (it is this appearance of the innermost layers in the fossil fruit which makes us suggest that the structure may be a dissepiment), but there is a slight difference, for in *Ochrosia* the criss-cross layers of fibres are interlaced with thick fibrous strands. Another difference between the fossil and living genus is that the seeds of *Ochrosia* are flat, not lentiform; but the testa is pitted as in the fossil. In many of its characters, therefore, the fossil species resembles *Ochrosia*, but its characters are not identical. The distribution of *Ochrosia* will be found on p. 479, under *Ochrosoidea sheppeyensis*. We have named the species now under consideration *Ochrosella ovalis*.

V. 23086 Holotype, figured Pl. XXVII, fig. 30. A fruit, one valve is detached in order to show the locule-cast, the remaining valve and adherent locule-cast is fractured transversely; it shows the structure of the carpel and the form of the locule in section.

V. 23087 Figured Pl. XXVII, fig. 31. Half of a fruit, showing two valves and the locule-cast and seed between them.

Both are Reid & Chandler Coll., Minster.

Family APOCYNACEAE ? (or ASCLEPIADACEAE ?)

Genus JENKINSELLA nov.

DIAGNOSIS.—Fruit ovoid, pointed at both ends, one-celled, many-seeded ?; placentation parietal ? along a ventral suture, exocarp formed of transversely aligned cells with many equidistant longitudinal strands of fibres; endocarp formed of transversely aligned fibres. Length, 8 to 11·4 mm.; diameter, 4 to 6 mm.

GENOTYPE.—*J. apocynoides* n. sp.

Jenkinsella apocynoides n. sp.

PLATE XXVIII, figs. 1–5.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 23088.

DESCRIPTION.—*Fruit:* Ovoid, tapering at both ends, with terminal style and attachments, one-celled, many-seeded ?, with a ventral suture and associated band of longitudinal fibres (Pl. XXVIII, figs. 1–3, 5) along which the seeds (or seed) were probably attached. Carpel wall, about 0·35 mm. thick, covered superficially by a coat of parenchyma (cells 0·013 mm. in diameter), within formed of two coats, an outer coat of transversely aligned cells in which are embedded many equidistant longitudinal strands of fibres giving the carpel a longitudinally ribbed appearance (Pl. XXVIII, fig. 4), and an inner coat formed of many layers of transversely aligned fibres. The inner coat is smooth and polished on its inner face (the locule-lining) as may be seen by its impression on the locule-casts (Pl. XXVIII, figs. 1, 3–5). Along the edges of the suture on the locule-cast are numerous evenly spaced small circular scars (Pl. XXVIII, fig. 3) which must represent the casts of fibro-vascular canals through which the bundles entered the locule. In some specimens these scars are in a single row on each side of the suture, in others there are two rows on each side, the scars of one row alternating with those of the other. The surface of the locule, as impressed upon the casts, is, in every instance, devoid of any other indication of a placenta; these scars probably, therefore, represent placentae. Length, 8 to 11·4 mm.; diameter, 4 to 6 mm.

Seed: The evidence as regards the seeds is extremely doubtful. The transverse sections of the locule-casts show no indication of seeds, either in section or in superficial view. But one cast, which is rather worn on the ventral face, shows what may be seeds lying transversely immediately within the locule. On the other hand, these possible seeds may be merely the ridged surface of yet another carpellary coat, as no definite outlines of seeds are visible in the cross-section of this cast. If seeds they be, however, they are linear, with the length transverse to the length of the fruit, and lie one above the other in the locule; their surfaces show fine striae in the direction of their length (the striae being 0·025 mm. apart), and rectangular or square cells 0·05 mm. across, but we do not know the relation between these two surfaces. A transverse section of the holotype shows a tangled mass of hairs lining the locule, which in the main have a transverse alignment; these may have been the pappus of seeds as in many Apocynaceae, or again they may be merely outgrowths from the locule wall.

Remarks and Affinities.—Six specimens from Herne Bay, and one from near Stanmore, Middlesex. All but one of the Herne Bay specimens are merely locule-casts. On this specimen the pericarp is preserved on the dorsal surface, but on the ventral surface the locule-cast is partly exposed, and where this is worn the seeds ? (or inner carpellary coat ?) are exposed within. The ventral suture and transverse alignment of the fibres in this species suggest that it may have been a follicle which gaped elastically along the ventral margin. This interpretation is confirmed by the Middlesex specimen, in which the ventral wall of the pericarp was originally preserved although in a decaying and crumbling condition; dehiscence had begun along the ventral suture so that pyrites had penetrated into the fissure produced and remained as a ridge. The follicular character and the shape of the fruit suggest very strongly relationship either with the Apocynaceae (cf. *Condylocarpon*, *Kopsia*), or the Asclepiadaceae. We know of no other families where similar fruits occur. In the follicular Rosaceae and Ranunculaceae, for instance, the fruits are not ovoid and the style is asymmetrically placed. Linear seeds, if they really occur, would point to relationship with the Apocynaceae rather than with the Asclepiadaceae, for in the latter family the seeds are large and usually flattened although they may sometimes be narrowed by longitudinal folding. The relationship with either one or other of these two families would be confirmed if the confused mass of hairs within the locule could be shown definitely to be the hairs of pappus-bearing seeds, but in the absence of further reliable information regarding the seeds the relationship of the specimens must remain doubtful. The locule-casts and fruits are, however, so readily recognizable that we have given them a distinctive generic name, *Jenkinsella*, after Mr. D. J. Jenkins, who collected them.

A figure given by Parkinson (1804, pl. VI, fig. 9) may perhaps represent this species.

V. 23088 Holotype, figured Pl. XXVIII, figs. 1, 2. A locule-cast, with part of the carpel wall preserved.
V. 23089 Figured Pl. XXVIII, fig. 3. A large locule-cast, showing very clearly the unworn transverse striations.
V. 23090 Figured Pl. XXVIII, fig. 4. A locule-cast, figured to show the dorsal surface.
V. 23091 Figured Pl. XXVIII, fig. 5. A locule-cast, showing a double row of scars on either side of the ventral suture.
V. 23092 Two locule-casts, both fractured transversely in an attempt to discover definite evidence of the seeds.
All the above are D. J. Jenkins Coll., Herne Bay.
V. 23093 A hollow cast of the locule with decayed remains of the pericarp. It shows follicular dehiscence. *H. A. Toombs Coll.*, Honeypot Lane, half a mile south of the "Green Man," South of Stanmore, Middlesex, from a sewer tunnel 72 feet below the summit of the hill.

Family BORAGINACEAE

Section *EHRETIOIDEAE*

Genus DAVISELLA nov.

Diagnosis.—Pyrene semi-ovoid with convex dorsal face, bisymmetric about a median plane, dorsal face with a deep median groove conspicuously pitted in symmetrically arranged longitudinal rows, two-loculed, germinating by two basi-lateral arcuate openings on the smooth ventral face. Length, 1·5 to 1·75 mm.; breadth, 1·2 mm.; thickness, 0·25 to 0·4 mm.

Genotype.—*D. ehretioides* n. sp.

Davisella ehretioides n. sp.

Plate XXVIII, figs. 6–9.

Diagnosis.—That of the genus.

Holotype.—V. 23094.

Description.—*Pyrene:* Two-loculed, semi-ovoid, the dorsal face being convex and the ventral face flat or slightly concave, bisymmetric about a median longitudinal dorsi-ventral plane, broadly emarginate at the base and narrowly emarginate at the apex; the dorsal face ornamented by large deep pits arranged symmetrically in a few longitudinal rows on each side of a conspicuous broad median groove (Pl. XXVIII, figs. 6, 8), the ventral face smooth (Pl. XXVIII, figs 7, 9). Pyrene germinating by a pair of elongate arcuate basi-lateral apertures on the ventral face, sub-parallel to the lateral margin, which open into the two locules (Pl. XXVIII, fig. 9). Pericarp thick and woody. Length of one specimen, 1·75 mm; breadth (distorted), 1·2 mm.; thickness (distorted), 0·25 mm. Length of second specimen, 1·5 mm.; breadth (distorted), 1·2 mm.; thickness (distorted), about 0·4 mm.

Affinities.—Two pyrenes from the Basement Bed of the London Clay at Harefield, Middlesex. Although the pyrenes were collected at the same time, and in the same locality, the difference of form makes it probable that they did not belong to the same fruit.

The form, size, and sculpture of these bilocular pyrenes indicates clearly that they are related either to the Boraginaceae or to the Verbenaceae, but only in the former family, in the sections Ehretioideae and Heliotropoideae, did we find comparable nutlets, and especially in the tropical genus *Ehretia* Linn. In this genus, the small globular fruits fall into two equal hemispherical pyrenes. Like the fossils, these pyrenes are bisymmetric and germinate by elongate, arcuate, basi-lateral apertures, sub-concentric with the margins. The dorsal surface of *E. acuminata* R. Br. has a series of pits larger and more irregular than those of the fossil and the pyrenes are much larger (2·75 by 2·5 by 1·5 mm.). In sculpture and size the fossil more resembles the pyrenes of *Heliotropium* Linn., but in this genus there are four one-celled, not two two-celled, nutlets, and the fruit does not germinate by arcuate apertures. It appears, therefore, that the fossil must be referred to the section Ehretioideae, and that it either belongs to the genus *Ehretia* or else is closely allied to it. We have named it *Davisella* after the finder, Mr. A. G. Davis.

A species of *Ehretia*, *E. cantalensis*, was recorded by E. M. Reid from the Mio-Pliocene of Pont-de-Gail (Cantal), France (1923, p. 348, pl. xi, fig. 21).

V. 23094 Holotype, figured Pl. XXVIII, figs. 6, 7. A pyrene.
V. 23095 Figured Pl. XXVIII, figs. 8, 9. A second pyrene, showing the germination valves distinctly.
Both are A. G. Davis Coll., Basement Beds of Harefield, Middlesex.

Family SOLANACEAE

Section *DATUREAE*

Genus CANTISOLANUM nov.

Diagnosis.—Fruit a multilocular, loculicidal capsule, seeds few, attached to the septa ; pericarp (as preserved) formed of radially aligned cells and lined by obliquely aligned cells. Seeds broadly oval, laterally compressed, with the hilum marginal and asymmetrically placed on one of the broad sides ; testa formed of cells with highly crenulate margins, 0·05 to 0·075 mm. in diameter ; greatest diameter of seed, 4·2 mm. ; least diameter, 3·3 mm. ; thickness, 1·5 mm.

Genotype.—*C. daturoides* n. sp.

Cantisolanum daturoides n. sp.

Plate XXVIII, figs. 10–12.

Diagnosis.—That of the genus.

Holotype.—V. 23096.

Description.—*Fruit:* A several-seeded capsule. The pericarp appears to have been dry and (as preserved) to have been formed of two coats. The outer of these is about 0·6 mm. thick, fairly compact, composed of irregular cells which are radially aligned. The inner coat, which formed the locule-lining, is represented (except for a few decayed cells) by its impression on the locule-cast. It is smooth, and the cells which formed it are aligned obliquely from a narrow longitudinal rib on the locule-cast (Pl. XXVIII, fig. 11). The rib may represent the line of dehiscence of a loculicidal capsule, or it may represent merely the impression of a longitudinal groove ; but the fact that a smooth break in an adhering portion of the pericarp is in direct continuation with the line of the rib (Pl. XXVIII, fig. 11) very strongly confirms that the dehiscence was in fact loculicidal. On the inner face of the specimen are the remains of a septum, alternate with the rib, along which dehiscence has not occurred. It is virtually certain, therefore, that dehiscence was loculicidal. The seeds are in close contiguity with this septum, on which were probably the placentas.

Seed: Broadly oval in outline, without any rim, bi-convex, but somewhat laterally compressed (Pl. XXVIII, figs. 10, 12). Testa formed of large deep polygonal cells, from 0·05 to 0·075 mm. in diameter, which have highly crenulate margins (Pl. XXVIII, fig. 10) ; hilum marginal asymmetrical on one of the longer sides. Greatest diameter in plane of symmetry, 4·2 mm. ; least diameter in same plane, 3·3 mm. ; thickness, 1·5 mm.

Remarks.—The one specimen shows a portion of the pericarp adhering to the upper part of a locule-cast (Pl. XXVIII, fig. 11), and on the inner face of the broken cast one large fully developed seed and three abortive seeds (Pl. XXVIII, fig. 10), as well as the remains of a septum embedded in the pyrites of the cast. After photographing the specimen in its original condition the seed was removed so as to show its complete form (Pl. XXVIII, fig. 12), and the hilum was then seen. All the seeds are in close proximity to the septum and the hilum was adjacent to it. It seems certain, therefore, that the placentas were on the septum.

Affinities.—On the evidence of the fragmentary carpel alone it would be very rash to suggest any definite position for this specimen, but the form of the seed with its marginal hilum, and deep polygonal cells with markedly crenulate margins are so highly characteristic of the Solanaceae that there can be no hesitation in placing the specimen in this family. The capsular fruit narrows the relationship greatly. Most of the fruits of the Solanaceae are berries, but a few are capsular. In the sub-section Hyoscyaminae they are circumscissile capsules. In the sub-section Nicotianinae and the section Salpiglossideae they are septicidal ; but in the section Datureae they may be loculicidal. Moreover, the placentation of the fossil seeds seems to be similar to that of the Datureae, and the seeds of *Datura* bear the closest resemblance of any of the Solanaceae to the fossil seed ; for the seeds of nearly all genera, although similar in shape, are very much smaller. In *Datura* the seeds of all species that we have seen approximate to the size of the fossil, although some are rather smaller ; others, like the seeds of *D. ferox* Linn., slightly larger (greatest diameter, 4·6 mm.), and yet others (*D. metel* Linn.) the same size. The testa, too, is similar and shows the same sort of nodular crumples. The testa cells in *D. metel* are of the same size and shape, but the crenulations are rather less marked. Nevertheless, the fossil fruit differs essentially in the structure of the pericarp. In *Datura* the pericarp is composed of very large thin-walled cells with no definite alignment. There are no coats to correspond with either of the coats in the pericarp of the fossil. Consequently, whilst referring the fossil to the section Datureae, we cannot refer it to any living genus. We have given it the name *Cantisolanum daturoides*.

V. 23096 Holotype, figured Pl. XXVIII, figs. 10–12. A seed lying in the remains of a capsule. *Bowerbank Coll.*, Sheppey.

Family ?

Genus POLYCARPELLA nov.

DIAGNOSIS.—Fruiting head a capitulum. Fruit an ovate achene much compressed laterally; pericarp formed of parenchyma, with embedded strands of fibres, greatly developed at the apex and thin below. Length of fruit, 4 mm.; greatest diameter, 2 to 2·5 mm.; least diameter, 0·75 to 1 mm. Seed sub-cylindric, micropyle towards the distal end of the fruit, chalaza towards the proximal end, anatropous? Length of seed, 1·8 to 2 mm.; diameter, 0·6 mm.

GENOTYPE.—*P. caespitosa* n. sp.

Polycarpella caespitosa n. sp.

PLATE XXVIII, figs. 13–21.

DIAGNOSIS.—That of the genus.

HOLOTYPE.—V. 23097.

DESCRIPTION.—*Fruiting head:* A capitulum, but, being broken and incomplete, it is uncertain whether it was originally globular or ovoid.

Fruit: Dry, indehiscent, obovate in outline but bilobed at the apex so as to be slightly emarginate (Pl. XXVIII, figs. 16–18), one lobe being broader than the other, compressed at right angles to the plane of the lobes, so as to have two nearly flat faces, one-loculed, one-seeded. Pericarp of unequal thickness. The sub-cylindric locule is situated in the lower half of the fruit. Here the pericarp is thin on the flat faces over the locule, but thick at the two edges, one edge being usually thicker than the other, so that the locule is not median. In the upper half of the fruit the pericarp consists of solid parenchyma throughout. Below, the carpel walls are formed of coarse, spongy parenchyma, within which several strands of sparsely branching fibres (carbonaceous) run from base to apex (Pl. XXVIII, figs. 17, 18). About five to seven such strands are seen on the outside of the fruit; all are truncated at the apex of the fruit as though originally they had been continued above. The strands arise from the fibrous axis of the capitulum; a little above the base of each fruit they diverge and then branch, so as to form the cup-shaped base of the locule. The locule-lining is smooth and formed of longitudinally aligned long fusiform or oblong cells. Length of fruit (rather variable), about 4 mm.; greatest diameter, 2 to 2·5 mm.; least diameter, 0·75 to 1 mm.

Seed: Sub-cylindric, rounded at the chalazal end (nearest the base of the fruit) and of a general wedge-shape at the opposite, micropylar end (Pl. XXVIII, figs. 20, 21). The two flattened faces are slightly convex transversely so that they meet at their lateral margins, where they are flanged, the flange on one side being more marked than that on the other ; towards the chalazal end of the seed the flanges die out ; the larger flange shows a carbonaceous core which probably represents the raphe ; one transverse section taken below the flange showed the circular section of the seed, and adjacent to it, and clasping it, is a crescentic section which would almost certainly be that of the raphe. At the end nearest the base of the fruit is a large circular scar from the centre of which the cells of the testa radiate ; this is undoubtedly the chalaza (Pl. XXVIII, figs. 20, 21). Hence the seed is probably, indeed almost certainly, anatropous and pendulous, although if we are mistaken in our observation of the raphe, it is erect and orthotropous. The micropyle is shown by a small apiculation at the opposite end to the chalaza (Pl. XXVIII, figs. 20, 21), from which the cells also radiate. The testa is rough externally, but its impression on the internal seed-cast is smooth and polished, showing the outline of irregular quadrilateral or polygonal cells with obscure longitudinal alignment. Length of seed, 1·8 to 2 mm. ; diameter, 0·6 mm.

Remarks and Affinities.—One specimen. The capitulum was already broken when it came into our hands and it was impossible to tell what had been its original form. Between seventy and eighty of the little fruitlets were counted when it was first seen, many adhering to the central axis, but they continually fell off as we examined the specimen, and now the whole capitulum has fallen to pieces.

We are at a loss where to place this capitular fruit. Some families are excluded by their campylotropous seeds (Alismaceae, Plantaginaceae), others by their erect anatropous seeds (Compositae, Cyperaceae) ; Platanaceae by its pendulous orthotropous seeds ; Rubiaceae, because those genera which have one pendulous anatropous seed in each locule are all two-loculed ; Valerianaceae and Dipsaceae, although they have pendulous and anatropous seeds, in no way resemble the fossil fruits in form or structure ; Plumbaginaceae also differ in their membraneous fruit ; Sparganiaceae have most characters in common, if we are right in regarding the seed as pendulous and anatropous. The fruits of *Sparganium* (the only genus in the family) are larger, they are not lobed above, and not compressed ; otherwise they are of the same general form, and the pericarp, like that of the fossil, is formed of spongy parenchyma with branching longitudinal strands of fibres embedded in it, and with a thick cap of parenchyma at the apex such as is seen in the fossil. But there is one most important difference which distinguishes the fossil from *Sparganium*, although possibly it may not entirely exclude it from relationship. In *Sparganium* germination takes place by the extrusion of a large plug associated with the wide stylar canal. In the fossil there is no evidence of any such plug, nor of any wide stylar canal. It seems more probable that it germinated by the splitting of the pericarp where it was thin. The absence of scales surrounding the fruit as in *Sparganium* we do not regard as a serious objection to an alliance because these delicate organs might have perished either during or before fossilization ; or it is even possible that the thick strands of fibres which are external to the pericarp may represent them. Typhaceae, represented by the single living genus *Typha*, a family closely allied to Sparganiaceae, although otherwise unlike the fossil, has the mode of dehiscence suggested as probable for the fossil fruits, by lateral splitting of the thin pericarp. If the strands of fibres should represent the calyx, as do the bristles of *Typha,* it would be an additional resemblance, although in the fossil they appear adnate (possibly only by being cemented with pyrites), whereas in *Typha,* although persistent, they are free. In any case the most probable position for the fruit would appear to be near the Sparganiaceae and Typhaceae.

V. 23097 Holotype, figured Pl. XXVIII, figs. 13–21. The remains of a fruiting head, now rapidly disintegrating; also four detached fruits and two seeds. *W. Griffiths Coll.,* Sheppey.

Genus LEYRIDA nov.

DIAGNOSIS.—Endocarp obovoid or globular, bony, multilocular, syncarpous, dehiscing by valves. Seeds pendulous, solitary in the locule. Seed sub-ovoid but compressed dorsi-ventrally, anatropous, chalaza sub-terminal, raphe lateral, testa much thickened over the hilum and raphe, formed of polygonal cells.

GENOTYPE.—*L. bilocularis* n.sp.

Leyrida bilocularis n. sp.

PLATE XXVIII, figs. 22–32.

DIAGNOSIS.—Endocarp obovoid with a large apical depression, two-loculed. Length, 9 to 10 mm.; greatest diameter, 6 to 7 mm.; least diameter, 4 to 6 mm. Seed length, 5·5 mm. Tegmen of oblong cells.

HOLOTYPE.—V. 23098.

DESCRIPTION.—*Endocarp:* Obovoid, roundly truncate at the apex and sometimes stipitate; apex with a funnel-shaped hollow, the purpose of which we have not been able to discover, as it does not seem to communicate with the locules, but it may communicate with a central fibre; the base shows evidence of a five-partite arrangement, generally seen as obscure radiating ridges which soon die out; it is pierced by a hole which may have been that by which a central strand of fibres entered the fruit, but we have not been able to trace any such strand except possibly in one specimen. The endocarp is frequently compressed, two-loculed with one pendulous seed in each locule; the locules, which are oval in transverse section, always have the longer transverse axes parallel to one another (Pl. XXVIII, fig. 27). Dehiscence is effected by throwing off large valves from the dorsal faces of the locules (Pl. XXVIII, figs. 26, 27). The endocarp is woody; surrounding each locule is a thick coat of concentrically-aligned transverse fibres, but with some sinuosities in the alignment; the coat is of fairly uniform thickness. The space between the locules is filled by woody tissue, the cells, which are aligned so as to radiate from the periphery of the fruit, becoming longer as they approach the axis. Two specimens measure respectively: Length, 9 mm.; greatest breadth, 7 mm.; least breadth, 6 mm. Length, 10 mm.; greatest breadth, 6 mm.; least breadth, 4 mm.

Seed: Conforming in shape to the locule. It is ovoid but compressed dorsi-ventrally, anatropous, with lateral raphe and a large black lateral sub-terminal chalaza (Pl. XXVIII, figs. 26, 28–32). The testa is formed of two coats: an outer coat, one-cell thick, of small polygonal cells (0·025 mm. in diameter), within which is a fairly thick coat of much smaller polygonal cells ; the area over the raphe is very much thickened, especially near the hilum ; the thickened area, which is clearly marked from the rest of the testa, is formed of a mass of irregular-sized cells (some on the outer surface measure 0·025 mm. by 0·025 mm. and 0·035 mm. by 0·015 mm., whilst within they are larger and may measure 0·1 mm. by 0·06 mm.) ; it quickly becomes narrower and diminishes in thickness (Pl. XXVIII, figs. 26, 28) ; within these two coats is the delicate lining of the seed (or tegmen ?) formed of oblong cells which give rise to delicate longitudinal striations ; these, on all sides of the seed, converge towards the chalaza, curving round the end of the seed in order to do so. Length of seed, 5·5 mm.

Remarks and Affinities.—Sixty-four fruits and many fragments, also six seeds. The affinities of these fruits will be discussed when we have described the next species, which also must be referred to the same genus.

V. 23098 Holotype, figured Pl. XXVIII, fig. 26. An endocarp, with one valve removed to show the seed lying within the locule. The specimen has also broken transversely.
V. 23099 Figured Pl. XXVIII, figs. 22, 25. An endocarp, with remains of the peduncle surrounded by pyrites.
V. 23100 Figured Pl. XXVIII, fig. 23. A second larger endocarp, without peduncle.
V. 23101 Figured Pl. XXVIII, fig. 24. A small endocarp, without peduncle, figured to show the basal scar of attachment.
V. 23102 Figured Pl. XXVIII, fig. 27. An endocarp, fractured transversely to show the two locules and evidence of valves, the edges of which are marked by infiltrated pyrites.
V. 23103 Figured Pl. XXVIII, fig. 28. A seed, broken on one side, detached from a locule. The coarse-celled thickened area can be seen associated with the hilum and proximal end of the raphe.
V. 23104 Figured Pl. XXVIII, fig. 29. Seed with testa removed to show the chalaza.
V. 23105 Figured Pl. XXVIII, fig. 31. Another detached seed, with remains of the locule-lining adhering to its surface. Figured to show the dorsal surface.
V. 23106 Figured Pl. XXVIII, fig. 30. Another similar specimen, figured to show the ventral surface.
V. 23107 Figured Pl. XXVIII, fig. 32. Another isolated seed, the hilar end broken, showing the sub-terminal chalaza very clearly.
V. 23108 An endocarp.
V. 23109 A fragment of an endocarp with part of a broken seed, which shows the thickness of the testa in the hilar region.
V. 23110 Eighteen endocarps and several fragments.
All the above are from the Bowerbank Coll., Sheppey.
V. 23111 Forty endocarps and several fragments. *Reid & Chandler Coll.*, Sheppey.

Leyrida subglobularis n. sp.

Plate XXVIII, figs. 33–36.

Diagnosis.—Endocarp sub-globular with a small apical depression. Length, 9 to 10 mm. ; diameter, 8 mm.

Holotype.—V. 23112.

Description.—*Endocarp :* Woody, sub-globular, two- or three-loculed with one pendulous seed in each locule ; dehiscing by throwing off dorsal valves from the faces of the locules (Pl. XXVIII, figs, 33, 36), the valves being about three-quarters of the length of the nut ; the locules are oval in transverse section, with the longer transverse axes tangential in the fruit. As in the last species, the locules are surrounded by several concentric layers of fibres having a general transverse alignment, but to some extent oblique, sinuous, and intermatted ; the fibrous shell has a greater, but less uniform, thickness than in the last species ; in one specimen over the middle of the ventral face of a developed locule it is thick, but thins out near the margins of the valves ; an abortive locule in the same specimen is surrounded by a shell of fibres of fairly uniform thickness. The space between the locules is filled by a mass of woody parenchyma the cells of which, towards the centre of the fruit, become more elongate ; towards the periphery of the fruit the parenchyma is closely packed between the locules ; in the valves the cells of this tissue, as seen in cross-sections of the fruit, are radially aligned ; around the axial region they are much decayed, possibly indicating that here the tissue was more spongy and soft. Length of one fruit, 10 mm. ; diameter, 8 mm. Length of a second fruit, 9 mm. ; diameter, 8 mm.

Seed: Conforming in shape to the locule, ovoid, but compressed dorsi-ventrally, anatropous, with lateral raphe and large sub-terminal chalaza. Testa formed, so far as it has been seen, of small irregular polygonal cells (0·025 mm. in diameter) ; over the raphe, as in the last species, the testa is greatly thickened, especially near the hilum ; the band of thickening becomes both narrower and thinner as it approaches the chalaza ; it is formed by cells smaller than the corresponding cells in *L. bilocularis* (the inner ones measuring 0·075 mm. by 0·03 mm.).

REMARKS.—Three specimens : one in the Bowerbank Collection is two-loculed ; two collected by ourselves have three locules. In every case, except over an abortive locule in one of the three-loculed specimens, the valves have come away, so as to expose the locule-cast with some of the locule-lining adhering to it, or the seed-cast with remains of the testa. When thus deprived of their valves, the faces from which they have fallen away are hollowed (Pl. XXVIII, figs. 33, 36), the intervening septa forming thick ribs between the hollows (Pl. XXVIII, figs. 34, 35). The specimens found by ourselves are much waterworn ; the best preserved was sectioned transversely and showed the characters which we have described. We can discover no differences in structure either of fruit or seed between the two- and three-loculed forms. We conclude, therefore, that they are merely varietal forms of one species ; the fact that in one of the three-loculed specimens one locule is abortive lends support to this suggestion.

AFFINITIES.—The affinities of the genus must be sought among fruits which have syncarpous woody endocarps with two or three locules, the locules being oval in cross-section and having the longer transverse axes directed tangentially ; which have one anatropous pendulous seed in each locule, with a lateral raphe and large sub-terminal lateral chalaza ; and which dehisce by throwing off large dorsal valves from each locule. The last character and others of minor importance exclude such families as Styracaceae, Symplocaceae, Rhamnaceae, Elaeocarpaceae, and Tiliaceae, and confine the possible relationship to the Cornaceae, because certain genera which germinate by very similar valves are excluded on account of other differences in structure : the Nyssaceae by their ventral raphe as well as by the structure of the endocarp and testa ; the Burseraceae by the structure of the inner layer of the endocarp, and the structure of the testa, as well as by the complete unlikeness in the arrangement of the seminal organs. Comparison with Cornaceae shows many points of resemblance besides the mode of germination. *Cornus*, which of all the genera in this family most resembles the fossil, is two-loculed, but the ovary may be three-loculed, and *Curtesia*, which is of the same family, has more than three locules ; the tissue of the hard endocarp is very similar, so is the form of the locule ; also some species of *Cornus* (*C. macrophylla* Wallich, for example) have deep cavities at the apex, but these definitely communicate with the locule, which is not the case with the fossil, also there is no coat of transverse fibres in *Cornus*. In spite of these last-mentioned differences in structure, the resemblances might point to inclusion in the family. Nevertheless, the evidence to be derived from the seeds seems to go against it, for whilst the seeds of *Cornus* may have a similar form to that of the fossil their structure is dissimilar. The testa in *Cornus* is formed of very loose tissue and is often fused with the endocarp, and there is no distinct large, circular chalazal scar. In *Benthamia*, which is a near ally of *Cornus*, the raphe is thicker at the hilar end, but it branches over the surface as it approaches the opposite end. We feel extremely doubtful, therefore, whether, in spite of the similar mode of germination, there is any relationship with the Cornaceae.

We have named the genus *Leyrida* in recognition of the great help we have received throughout our study of the London Clay flora from the eminent authority on the Malayan flora, Mr. H. N. Ridley, F.R.S., but we are precluded from directly using his name because all suitable derivatives have already been applied to living plants. We have, therefore, had recourse to an anagram.

V. 23112 Holotype, figured Pl. XXVIII, figs. 33–35. An endocarp, fractured to show the number of locules. Two valves have been detached in fossilization so that the locule-casts are exposed. *Reid & Chandler Coll.*, Sheppey, 1928.

V. 23113 Figured Pl. XXVIII, fig. 36. A two-loculed endocarp with valves detached, revealing the seeds. *Bowerbank Coll.*, Sheppey.

V. 23114 An endocarp with three locules, from which the valves have come away. *Reid & Chandler Coll.*, Sheppey.

Genus NEURORAPHE nov.

Diagnosis.—Seed obovoid, anatropous, with hilum sub-terminal, raphe on reaching the chalaza branching to form five or six longitudinal strands, which become thinner as they pass backwards towards the hilar end of the seed. External chalaza small and raised, internal chalaza large and circular. Size and form very variable. Length, 8 to 12 mm.

Genotype.—*N. obovatum* n. sp.

Neuroraphe obovatum n. sp.

Plate XXVIII, figs. 37–42.

1879. *?Hightea elliptica* Bowerbank (pars) : Ettingshausen, p. 395.
1879. *Cotoneaster Sheppyensis* Ettingshausen (pars), p. 395.

Diagnosis.—That of the genus.

Holotype.—V. 23115.

Description.—*Seed:* Obovoid, variable in size and shape, often distorted (? the result of mutual pressure of many seeds in the fruit); anatropous, with the hilum, a small oval sub-terminal scar, at the narrow end, the chalaza at the broad end (Pl. XXVIII, figs. 38, 40, 41), and the raphe lying between them; at the chalaza the raphe divides into five or six longitudinal strands, which are fairly regularly spaced around the circumference of the seed and pass in a reverse direction towards the narrow end of the seed, the strands tapering slightly and occasionally bifurcating, but not anastomosing; when the testa and external chalaza are preserved the strands appear to branch from a central point (Pl. XXVIII, fig. 37), but when worn away so that the oval or circular scar of the internal chalaza alone remains, they diverge from its margin (Pl. XXVIII, fig. 40); this change of appearance is doubtless due to the thickness of the chalazal cap which does not permit of the impression appearing on the seed-cast, except beyond its margin; the micropyle is terminal and adjacent to the hilum (Pl. XXVIII, fig. 42); testa formed of the following coats from without inwards: (1) A coat of uniform woody equiaxial cells, (as preserved) about 0·3 or 0·4 mm. thick, but always somewhat abraded, and usually destroyed except in a few isolated patches, the cells measuring about 0·025 mm. in diameter, and having a tendency to transverse alignment; (2) a coat about 0·1 mm. thick formed of equiaxial polygonal cells about 0·006 mm. in diameter; (3) a thin coat of polygonal cells of irregular form, about 0·016 mm. in diameter; sometimes these coats remain united, sometimes they are separated by layers of pyrites, or one coat may have separated into two or more layers; the tegmen is formed of elongate thin-walled cells (about 0·016 mm. in diameter) with faceted or tapering ends, longitudinally aligned over most of the surface so as to produce longitudinal striae, but transversely aligned around the micropyle. Length of a large seed, 12 mm.; greatest diameter, 9·5 mm.; least diameter, 7 mm. Length of a smaller seed, 8 mm.; greatest diameter, 6 mm.; least diameter, 5 mm.

Remarks.—About twenty-five seeds in various states of abrasion, and a few fragments. None is perfect, few show any traces of the hilum or of the branching of the raphe. The outer coat of the testa is always much worn, and is usually separated from the inner coats by a film of pyrites along which it tends to break away, exposing the raphe and chalaza.

Affinities.—The size and form of these seeds, and the longitudinal fibres recall the seeds of some of the Malvales, of *Akania* (Akaniaceae) and of *Artocarpus* (Moraceae). The Malvales must be excluded from relationship on account of the distinctive structure of the testa (cf. pp. 395, 399, and text-fig. 14), which is unlike that just described. A conspicuous and constant feature in the Malvales is the close, compact coat, columnar in section. The resemblance to *Akania* is closer, the living species *A. Hillii* Hook f. being similar in appearance but smaller in size. The layers of the testa also are not quite comparable, and the longitudinal fibres are more slender and tortuous especially towards the chalaza. The living genus *Akania* is restricted in its distribution to a few places near the coastal rivers of southern Queensland and northern New South Wales. *Artocarpus* is also distinct from the fossil, both in its coats and in its chalaza, which has no large well-defined internal scar.

We are at a loss, therefore, as to the true relationship of these seeds, but on account of their distinctive characters we have given them a new generic name, *Neuroraphe*. Although some of the seeds were labelled "*Hightea attenuata* Bowerbank" by Ettingshausen, they have no connexion with any species of Bowerbank's genus *Hightea* (cf. p. 439). Ettingshausen regarded *H. attenuata* as a synonym for *H. elliptica* Bowerb. Three seeds were associated with other fossil fruits by Ettingshausen and labelled "*Cotoneaster Sheppyensis*." They do not bear even a superficial resemblance to *Cotoneaster*.

V. 23115 Holotype, figured Pl. XXVIII, fig. 37. A seed, much worn but with remains of outer coat of testa still preserved. The raphe branches at the apex (chalaza) of the seed. *Reid & Chandler Coll.*, Minster, 1929.
V. 23116 Figured Pl. XXVIII, fig. 38. A seed, somewhat distorted by pressure during growth.
V. 23117 Figured Pl. XXVIII, fig. 39. A seed, broken. It shows the chalaza, fibres, and cell-structure.
V. 23118 Figured Pl. XXVIII, figs. 40, 41. A seed much worn, so that the internal scar of the chalaza is exposed.
V. 23119 Figured Pl. XXVIII, fig. 42. A seed, broken. It shows the cast of the micropylar canal protruding through the remains of the testa.
V. 23120 Two seeds, much worn so that the external layers of the testa are gone and the internal chalazal scar is exposed.
V. 23121 Three seeds. One is broken and imperfect, but a fragment of testa is preserved at the hilar end, and the specimen apparently shows the hilar scar. These seeds were in a jar, with other genera, labelled by Ettingshausen "*Cotoneaster Sheppyensis*."
V. 23122 A seed, internal cast with detached remains of testa.
V. 23123 An abraded seed showing the internal chalaza. *Reid & Chandler Coll.*, Warden Point, 1928.
V. 23124 Five seeds in various states of abrasion. In some the internal chalaza is exposed. *Reid & Chandler Coll.*, Minster, 1929.
V. 23125 Eight abraded seeds and numerous fragments.

Unless otherwise stated, the above are from the *Bowerbank Coll.*, Sheppey. Of these, all except V. 23121 were labelled by Ettingshausen "*Hightea attenuata* Bowerb.," which in his printed list is given as a synonym for *H. elliptica*.

Genus LAGENOIDEA nov.

Diagnosis.—Fruit superior, segmented longitudinally, two- to four-loculed, syncarpous, each locule one-seeded, dehiscing by thick valves, each valve formed of two united segments; exocarp very thick, formed of radially aligned cells; endocarp pyramidal in form; locules sub-lagenoid, compressed dorsi-ventrally. Seed probably erect, orthotropous.

Genotype.—*L. trilocularis* n. sp.

Lagenoidea trilocularis n. sp.

Plate XXIX, figs. 1–18.

1879. *Chamaerops borealis* Ettingshausen, p. 393.
1879. *Euphorbiophyllum eocenicum* Ettingshausen, p. 394.
1879. *Apeibopsis variabilis* (Bowerbank): Ettingshausen (pars), p. 395.
1879. *Wetherellia variabilis* Bowerbank: Ettingshausen (pars), p. 396.

Diagnosis.—*Fruit:* Sub-globular, three- (rarely four-) loculed; endocarp with three or four sharp angles which protrude between the valves of the exocarp and reach nearly to the circumference. Length, 7 to 14 mm.; diameter, 8 to 23 mm.; locule-cast length, 3·5 to 4·5 mm.; greatest diameter, 2 mm.; least diameter, 1 mm.

Holotype.—V. 23126.

DESCRIPTION.—*Fruit:* Superior, syncarpous, sub-globular or bluntly angled, three- (or very rarely four-) loculed, with one seed in each locule, formed of a thick exocarp segmented on the exterior (Pl. XXIX, figs. 3, 4, 6, 7), the segments being twice as numerous as the locules and separated from one another by grooves which extend from base to apex; a pair of segments covers each flat face of the endocarp, which is a triangular or quadrangular pyramid (Pl. XXIX, figs. 12, 18). In some specimens, owing to abrasion, the angles of the endocarp protrude, at the base, between the pairs of large segments, giving rise to a corresponding number of small segments which do not reach the apex (Pl. XXIX, fig. 7). The locules are small, flask-shaped with the neck directed upwards, oval in cross-section with the major axes tangential, *i.e.* parallel to the flat faces of the endocarp (Pl. XXIX, figs. 6, 7). Germination takes place by the removal of large valves from the dorsal faces of the locules, each valve being formed externally of two of the segments of the exocarp, and internally by a flat face of the endocarp (Pl. XXIX, fig. 7). The pericarp presents the following succession of coats: (1) The exocarp, formed internally of a great thickness of polygonal thin-walled cells which pass almost imperceptibly into longer and longer cells as they reach the periphery, where they have a marked radial alignment (Pl. XXIX, fig. 8). These cells are transversely (spirally?) thickened; when a valve is removed there is seen a locule-cast, flanked by the smooth faces of the remaining valves (Pl. XXIX, fig. 1); each of these smooth faces shows a strong longitudinal strand of fibres which arises from the margin of the area of attachment (Pl. XXIX, figs. 1, 8; cf. also figs. 19, 20, 25). As they ascend, these strands throw off to the periphery, at approximately corresponding levels, branches which appear to be concerned with dehiscence; a little above the level of the apex of the locule the strands again branch, one branch of each passing to the apex of the fruit and one bending down towards the locule, which, together, they enter by its bottle-neck (cf. Pl. XXIX, figs. 19, 20); it must be observed that the pair of branches thus entering the locule originate from separate strands. It seems most unlikely, therefore, that they form the funicle of a pendulous seed; they are more probably concerned with the nourishment of the carpel. (2) The endocarp (usually partly carbonized) is thick, and is formed externally of parenchymatous cells radially aligned, and internally, near the locule, of elongate cells transversely aligned. The locule is lined by elongate, clawed, interlocking cells which produce a complicated pattern on the locule-cast; the inflated bodies of the cells give rise to longitudinal striations, the claws forming obscure transverse striations or crumples which usually can be seen only as impressions on the locule-cast. The endocarp commonly adheres to the exocarp, but very rarely it remains as a separate entity (Pl. XXIX, figs. 11, 12; cf. also fig. 18, in which the locule-cast is covered by endocarp). Occasionally the remains of a calyx are preserved at the base of the fruit (Pl. XXIX, figs. 5, 9, 10). We have already seen that the seed is probably not pendulous; it is therefore probably erect. Measurements of three typical specimens are as follows: (1) Length, 14 mm.; diameter, 23 mm. (2) Length, 11 mm.; diameter, 14 mm. (3) Length, 7 mm.; diameter, 8 mm.

Seed: Conforming in shape to the locule, ovate-lanceolate in outline, somewhat compressed dorsi-ventrally; almost certainly erect and orthotropous, since the large, round chalaza is at the proximal end of the seed and there is no evidence for a pendulous seed. The chalaza is placed somewhat asymmetrically, nearer the ventral than the dorsal side (Pl. XXIX, fig. 16). Testa thin, formed of minute square cells, aligned in longitudinal rows, which, owing to longitudinal crumplings, give the surface a fibrous appearance, especially near the apex; the internal seed-cast shows the impression of a smooth, shining layer of delicate parallel-sided cells, much elongate longitudinally, and with tapering or faceted ends. The remains of the chalaza adhere to this coat. Two locule-casts (virtually equivalent in size to seeds) measure respectively: Length, 4·5 mm.; greatest diameter, 2 mm.: least diameter, 1 mm. Length, 3·5 mm.; greatest diameter, 2 mm.; least diameter, 1 mm.

REMARKS.—Over seventy fruits and numerous fragments, ten locule-casts, one seed-cast, and two calices from Sheppey, and one fruit from Brentwood, Essex. The fruits occur in various stages of preservation. Very frequently the valves have fallen free and are found separately, sometimes with the locule-casts adhering to them (Pl. XXIX, fig. 8), but more commonly these remain attached to the axis. Sometimes the pericarp is so decayed that the bases of the locule-casts protrude (Pl. XXIX, figs. 6, 7). It was to one such specimen that Ettingshausen gave the name *Euphorbiophyllum eocenicum* (Pl. XXIX, fig. 6). When decay is carried further the locule-cast may fall out (Pl. XXIX, fig. 7). A four-loculed fruit of very rare occurrence seems to belong to this species since the septa and axis are similar (Pl. XXIX, fig. 3).

AFFINITIES.—It will be best to defer any discussion on the affinities of this genus until we have described the next species.

V. 23126 Holotype, figured Pl. XXIX, fig. 1. A fruit with a valve removed so as to show the locule-cast and the structure of the pericarp.
V. 23127 Figured Pl. XXIX, fig. 3. A rare four-loculed fruit, now rapidly falling to pieces.
V. 23128 Figured Pl. XXIX, fig. 4. A large fruit.
V. 23129 Figured Pl. XXIX, fig. 6. A fruit, worn at the base so that the locule-casts are seen. The specimen was labelled by Ettingshausen "*Euphorbiophyllum* . . .," the label being partly obliterated.
V. 23130 Figured Pl. XXIX, fig. 9. A calyx, detached from a fruit, figured to show the under side.
V. 23131 Figured Pl. XXIX, fig. 10. A calyx, detached from a fruit, figured to show the upper surface. Part of the fruit from which it was obtained is also preserved.
V. 23132 Figured Pl. XXIX, fig. 16. The internal cast of a seed showing the chalaza. The seed is broken at the micropylar end.
V. 23133 Figured Pl. XXIX, figs. 17, 18. A fruit now fractured to show the structure. *A. G. Davis Coll.*, Brentwood, Essex.
V. 23134 Two fruits.
V. 23135 Thirty fruits and several fragments.
V. 23136 Two fruits, broken, labelled by Ettingshausen "*Chamaerops borealis* sp. n."
V. 23137 Numerous fragments of fruits.
V. 23138 Ten locule-casts detached from fruits.

All the above are from the Bowerbank Coll., Sheppey, except V. 23133.

V. 23139 Six fruits. *Reid & Chandler Coll.*, Sheppey, 1928.
V. 23140 Eighteen fruits and some fragments. *Reid & Chandler Coll.*, Minster, 1929.

The following were labelled by Ettingshausen "*Apeibopsis variabilis*": V. 23126–32, V. 23134, V. 23137–38. The originals of Pl. XXIX, figs. 2, 5, 7, 8, 11–15, were also similarly labelled by Ettingshausen. They have now decayed, as have others labelled "*Wetherellia variabilis*."

Lagenoidea bilocularis n. sp.

PLATE XXIX, figs. 19–27.

DIAGNOSIS.—Fruit sub-ovoid, laterally compressed, two-loculed, with six longitudinal segments, the two pairs of end segments forming the two valves, the narrower segments between them being the protruding sides of the endocarp; endocarp four-sided, the sides facing the valves concave, those between the valves broadly truncate externally. Length, 8 to 15 mm.; greatest diameter, 8 to 15 mm.; least diameter, 5 to 8·5 mm.

HOLOTYPE.—V. 23141.

DESCRIPTION.—*Fruit:* Two-loculed, syncarpous, sub-ovoid, somewhat laterally compressed, oval in cross-section (Pl. XXIX, figs. 23, 26), showing externally six longitudinal segments which extend from base to apex and are separated by slight grooves (Pl. XXIX, figs. 21, 22, 24); the two pairs of end segments form the valves which, as in *L. trilocularis*, cover the locules, one pair to each valve (Pl. XXIX, fig. 26); the narrow intermediate lateral segments are the free ends of the endocarp, which in this species always reach the surface; the species also differs from *L. trilocularis* in that the wedges of endocarp which lie between the valves are broader at the periphery than at the locules, whereas in *L. trilocularis* they are narrower (cf. Pl. XXIX, fig. 7). The cell structure of exocarp, endocarp (Pl. XXIX, fig. 27), and seed, also the form of locule and seed (Pl. XXIX, figs. 19, 25) are identical with the corresponding features in *L. trilocularis*, so that the locule-casts and seeds of the two species cannot be distinguished from one another. Two typical fruits measure respectively: (1) Length, 15 mm.; greater diameter, 15 mm.; lesser diameter, 8·5 mm. (2) Length, 8 mm.; greater diameter, 8 mm.; lesser diameter, 5 mm.

REMARKS AND AFFINITIES.—Fifty-two fruits and sixty fragments belong to the Bowerbank Collection, and 130 complete fruits and about 100 fragments were collected by ourselves; there are also five locule-casts which we dissected from fruits. The two species together rank among the most abundant of the Sheppey fruits. In seeking for the relationship of the genus to which both evidently belong, there are certain outstanding characters which must be taken into account: The two- or three- (occasionally four-) loculed fruit with one seed in each locule, dehiscing by throwing off dorsal valves, the ovate-lanceolate form of the locule, the seed oval in section and with the longer transverse axis tangential, the (almost certainly) erect orthotropous seed. The only family that in any degree fulfils the requirements seems to be the Polygonaceae. But although the fruits of this family are formed from three carpels and dehisce septicidally, there is only one locule; and although the erect orthotropous seeds are narrowed towards the micropyle, they have not the beautiful attenuated form of the fossil seeds. The only family known to us with seeds of similar form is the Cyperaceae, but with this the likeness begins and ends. We think it probable that the family to which the fossil genus belongs is now extinct.

V. 23141 Holotype, figured Pl. XXIX, figs. 19, 20. A small fruit, with valves detached to show the two locules and the structure of the carpel wall.

V. 23142 Figured Pl. XXIX, fig. 21. A fruit, showing a rare form, broader at the top than at the bottom.

V. 23143 Figured Pl. XXIX, fig. 22. A typical fruit.
V. 23144 Figured Pl. XXIX, fig. 23. A typical fruit, figured to show the apex.
V. 23145 Figured Pl. XXIX, fig. 24. A fruit, figured to show the base.
V. 23146 Figured Pl. XXIX, fig. 25. A fruit, with a valve detached to show the locule-cast and carpel wall.
V. 23147 Figured Pl. XXIX, fig. 26. A fruit, rubbed down to expose a transverse section. The two locules are seen within the endocarp.
V. 23148 Figured Pl. XXIX, fig. 27. A fruit, with part of the carpel wall removed parallel to the major transverse axis. It shows parts of the two locule-casts, and within one, a portion of the seed. The structure of the carpel is very clearly shown.
V. 23149 Four well-preserved specimens, one with a valve removed.
V. 23150 Forty fruits and about sixty half-fruits and many fragments.
All the above are from the Bowerbank Coll., Sheppey.
V. 23151 Six fruits. *Reid & Chandler Coll.*, Sheppey.
V. 23152 125 fruits. *Reid & Chandler Coll.*, Minster.
V. 23153 100 broken fruits and fragments. *Reid & Chandler Coll.*, Minster.
V. 23154 Five locule-casts. *Reid & Chandler Coll.*, Minster.
V. 23155 An admixture of seeds of *L. trilocularis* and *L. bilocularis*. *Bowerbank Coll.*, Sheppey.

Genus LAGENELLA nov.

Diagnosis.—Endocarp woody, syncarpous, two-loculed, with one seed in each locule, four-faced and four-angled, the angles forming thin flanges, bisymmetric about two vertical planes at right angles to one another ; one pair of opposite faces obovate in outline, concave transversely, convex longitudinally ; the other pair ovate, and concave both longitudinally and transversely. Length, 9·5 to 13·5 mm. ; breadth of obovate face, 4·25 to 7 mm. ; breadth of ovate face, 6 mm. Seed ovate-lanceolate in outline, dorsi-ventrally compressed, testa longitudinally striate, tegmen formed of thin-walled parallel-sided cells. Length, 4·75 mm.

Genotype.—*L. alata* n. sp.

Lagenella alata n. sp.

Plate XXIX, figs. 28–34.

Diagnosis.—That of the genus.

Holotype.—V. 23156.

Description.—*Fruit:* Woody, syncarpous, two-loculed, with one seed in each locule, four-faced and four-angled, the angles being produced into comparatively thin flanges, bisymmetric about two vertical planes at right angles to one another, which bisect the four faces ; one pair of opposite faces obovate or sub-quadrilateral in outline, concave transversely but convex longitudinally (Pl. XXIX, figs. 29-32) ; the other pair ovate in outline, convex both transversely and longitudinally (Pl. XXIX, figs. 28, 30–32), and with a median ridge or large tumidity from which the horizontal wrinkles on the flanges diverge (Pl. XXIX, fig. 28). The locules, which are ovate-lanceolate in outline and oval in cross-section (the two transverse axes bearing the proportion to one another of two to five) are arranged with the longer transverse axes parallel to one another and to the concave faces of the fruit (Pl. XXIX, fig. 30). Dehiscence by removal of a valve from the dorsal face of each locule ? (cf. Pl. XXIX, fig. 30). We have observed the following coats, passing outwards from the locules: (1) The locule-lining, which is transversely wrinkled, but we have not seen the form of the cells which compose it. (2) External to this is a coat (sometimes partly carbonized) of woody parenchyma, thicker on the dorsal than on the ventral sides of the locules. The cells forming it are irregular in outline, radially aligned, and in surface view more or less transversely aligned. It is possible that their impressions produce the wrinkles on the locule-lining already described. (3) External to this coat is a thick one formed of longitudinal fibres, but we are uncertain whether or not they form a complete cylinder. These longitudinal fibres give off, throughout the whole length of the fruit, successive horizontal layers of fibres which fan out towards the four angles, where they form the flanges already described. Towards the apex the longitudinal fibres surround the attenuated apex of the locule, but whether any actually enter the locule we have not been able to discover; the form of locule makes it unlikely. A strand of fibres does pass, however, from the apex of each locule towards the periphery of the fruit, reaching the exterior by a pair of oval apertures, one at the apex of each obovate face (Pl. XXIX, fig. 29). These strands appear to be connected with the styles, and in one fruit the two strands seem to unite at the apex of the fruit. The fibrous bands are embedded within a mass of parenchyma which is particularly thick on the tumidities of the ovate faces. (4) The external surface cells cannot be distinguished; the contours of the surface are very uneven. Length of large fruit, 13·5 mm.; breadth of obovate face, 7 mm.; breadth of ovate face, 6 mm. Second specimen, length, 10 mm.; breadth of obovate face, 4·25 mm.; breadth of ovate face, 6 mm. Third specimen, length, 9·5 mm.; breadth of obovate face, 5 mm.; breadth of ovate face, 6 mm. Length of locule-cast, 4·75 mm.

Seed: The seed conforms in shape to the locule, which it fills when fully developed. It is therefore ovate-lanceolate in outline and compressed dorsiventrally. The chalaza is large and oval, near the base on one of the narrow margins. It is placed asymmetrically both as regards the dorsi-ventral faces and the two margins, for more of its surface lies on the ventral than the dorsal side of the seed, and the oval scar is carried higher on one margin, where it also narrows, than on the other (Pl. XXIX, fig. 34). This arrangement of the chalaza suggests that the seed was anatropous; on the other hand, we have been unable to find any evidence of a raphe or of any suspension of the seed from the apex of the locule, and the form of the seed in other respects suggests an orthotropous rather than an anatropous seed. The testa is very thin, longitudinally striate and finely ribbed. The cells composing it are, over the greater part of the surface, narrow and aligned longitudinally, but near the narrow lateral part of the chalaza they are elongate, sinuous and aligned confusedly. The tegmen has a smooth and glistening surface and is formed of long delicate thin-walled parallel-sided cells with attenuated or faceted ends.

Remarks and Affinities.—Ten specimens, nine from Minster and one from Herne Bay. All were perfect. Another specimen, now completely disintegrated, was in the Bowerbank Collection. We are quite unable, after the most careful examination of the specimens, to ascertain either the way in which the seed is attached, or whether it is anatropous or orthotropous. We have examined every living family which we know to have two-loculed, one-seeded fruits, taking account of both possibilities of attachment and arrangement, but in none can we find comparable fruits and seeds. Two-loculed bony endocarps with bisymmetry in two planes at right angles to one another occur in Cornaceae (*Cornus* among living genera, and certain extinct genera), Tiliaceae (*Grewia*), Pedaliaceae (*Pedalia* and *Pterodiscus*). No member of these families has locules and seeds of similar shape attenuated to a long point at the apex; and in none are the parenchyma and fibres of the bony endocarp similarly arranged. Again, so far as we have been able to examine the seeds of these families, all but those of *Grewia* differ essentially in the cell characters of testa and tegmen, and the size and form of the chalaza. *Grewia* does show a similar testa and tegmen, also the chalaza, as in most Tiliaceae, is large, but the raphe is a very conspicuous lateral appendage, and the seed instead of being attenuate is ovoid. The locules, again, are scarcely compressed, the endocarps are very much smaller and their walls throughout appear to be formed of woody parenchyma. Therefore, whilst it is just possible that there may be some relationship to the Tiliaceae, the correspondences in regard to the testa, tegmen and chalaza of *Grewia* are not in themselves sufficient to justify any reference to the family.

The question must naturally arise as to whether or not there is relationship between this genus and *Lagenoidea*. The form and arrangement of the locule, the structure of the testa, and in some degree of the pericarp are so remarkably alike that it seems highly probable. At the same time the mode of germination of *Lagenella* is very uncertain. There is some evidence that the whole of the concave faces, including the whole of the wings, may have come away as large dorsal valves—see the right-hand locule in Pl. XXIX, fig. 30, from the upper end of which a fine white line can be traced to the periphery of the fruit, suggesting an incipient fissure along which pyrites has entered, and therefore suggesting a valve; but the evidence is by no means conclusive. It seems highly probable that the two genera belong to the same (extinct ?) family, but that the species under discussion does not belong to the same genus as the other two species. We have given it the name *Lagenella alata*.

V. 23156 Holotype, figured Pl. XXIX, figs. 28–32. A fruit, fractured transversely to show the structure. *Reid & Chandler Coll.*, Minster, 1928.
V. 23157 Figured Pl. XXIX, fig. 33. A fruit, dissected to show the two locule-casts. *Reid & Chandler Coll.*, Minster, 1929.
V. 23158 Figured Pl. XXIX, fig. 34. A fruit, dissected to expose the seed with its chalaza. *Reid & Chandler Coll.*, Minster, 1929.
V. 23159 Six fruits. *Reid & Chandler Coll.*, Minster, 1929.
V. 23160 A fruit. *D. J. Jenkins Coll.*, Herne Bay.

Genus CARPOLITHUS Linnaeus

1768. Syst. Nat., ed. 12, iii, p. 172.

Carpolithus subfusiformis (Bowerbank)

PLATE XXX, figs. 1–5.

1840. *Cupressinites subfusiformis* Bowerbank, p. 56, pl. x, figs. 35, 36.
1845. *Cupressites subfusiformis* (Bowerbank) Unger, p. 192.

1847. *Frenelites subfusiformis* (Bowerbank) Endlicher, p. 9.
1850. *Frenelites subfusiformis* (Bowerbank) : Unger, p. 344.
1879. *Cupressinites subfusiformis* Bowerbank : Ettingshausen, p. 392.

DIAGNOSIS.—Fruit fusiform, three- to four-partite and valvate, syncarpous, seeds numerous, placentation parietal, pericarp fibrous, inner layers of fibres longitudinal, outer layers transverse. Length, 11 to 12 mm. ; diameter, 8 to 13 mm. Seed small, flattened, with a tubercled testa, columnar in section.

HOLOTYPE.—V. 23161.

DESCRIPTION.—*Fruit :* The species is represented by three specimens. All are internal casts to which greater or less portions of the pericarp adhere. Two show a tripartite arrangement and one a four-partite arrangement. We will describe them separately.

A broadly fusiform specimen (V. 23162, Pl. XXX, figs. 1–3) shows a four-partite locule-cast with the remains of the pericarp at the base. It is hollow, and since the impression of the fibres of the pericarp is continuous over the whole surface, except where interrupted by longitudinal ridges, it seems to have been one-loculed. The remains of the pericarp show that it was formed of a thick outer coat of many layers of transversely directed fibres, and an inner thinner coat of fibres which have a general longitudinal direction, but diverge obliquely from the midrib of each carpel. The locule-cast shows on its surface two sets of four longitudinal ridges of pyrites, one set at the top and the other at the bottom, the two sets alternating in position and neither reaching the equator of the cast, where all the ridges have died out (Pl. XXX, fig. 1). The upper ridges are formed entirely of pyrites, and therefore must represent the infilling of fissures formed by gaping valves. The lower ridges each carry a central longitudinal strand of fibres (evidenced by the impressions) which arise from the base (Pl. XXX, fig. 2). These must, therefore, represent canals with a central strand of fibres, and, as we shall see later, probably indicate parietal placentation. Length (as crushed from base to apex), 11 mm. ; breadth (increased by same cause), 13 mm.

A rather similar cast, except that it was tripartite, was described by Bowerbank as *Cupressinites subfusiformis* (V. 23161). It shows similar coats and structure, but the pericarp being in a better state of preservation, the vascular bundles within the basal ridges are less conspicuous. We can find no evidence, either macroscopic or microscopic, for referring this specimen to the Cupressineae. It was probably a general resemblance in form which misled Bowerbank.

A third specimen (V. 23163, Pl. XXX, figs. 4, 5), found by ourselves in 1928, is ovoid and smaller than the other two. It shows a tripartite arrangement. Although considerably worn externally, much more of the pericarp is preserved than in the other two specimens and there is definite evidence, both superficially and in transverse section, of the valves. These are long and originally must have reached almost the full length of the fruit, although now they are much worn at the apex ; unlike the two other specimens this one has grooves at the base instead of ridges, but merely because the canals which carried the fibres have been broken into. A longitudinal section shows the external impressions of one or two small flattened seeds with minute portions of the testa. They lie close to the carpel wall and to one of the fibrous ribs, and one shows evidence of having communicated with the ribs by a canal—thus suggesting parietal placentation. The testa is columnar in section and the impression of its outer surface shows that it was finely tubercled. Length of fruit, 12 mm. ; diameter, 8 mm.

REMARKS AND AFFINITIES.—The general form of these fruits and the identity of structure seen in the pericarp, and in the mode of dehiscence, leave no doubt that they represent a single species which could be either three- or four-partite. It appears, therefore, that its affinities must be sought among three- or four-carpelled, syncarpous, one-loculed, many-seeded fruits with parietal placentation and valvular dehiscence, the pericarp being formed, in part at least, by a thick coat of fibres. We have failed to relate it to any living family.

V. 23161 Holotype, figured Bowerbank 1840, pl. x, figs. 35, 36. A three-loculed fruit with remains of the pericarp. Collected by Thomas Hunt of Herne Bay. *Bowerbank Coll.*

V. 23162 Figured Pl. XXX, figs. 1–3. A four-partite fruit, showing a locule-cast with remains of the pericarp at the base. *Bowerbank Coll.*, Sheppey.

V. 23163 Figured Pl. XXX, figs. 4, 5. A three-loculed fruit with much of the pericarp preserved. Now fractured both longitudinally and transversely, showing valves in place, and seeds. *Reid & Chandler Coll.*, Sheppey.

Carpolithus tessellatus (Bowerbank)

1840. *Cupressinites tesselatus* Bowerbank (pars), p. 63, pl. x, figs. 26, 27.
1845. *Cupressites tesselatus* (Bowerbank) Unger, p. 193.
1847. *Passalostrobus tessellatus* (Bowerbank) Endlicher, p. 14.
1850. *Passalostrobus tesselatus* (Bowerbank) : Unger, p. 350.

Bowerbank groups under this name three specimens, and figures two of them (1840, pl. x, figs. 26, 27, 30, 31) which, he says, " all agree in the number, form, and mode of arrangement of the parts of which they are composed. When not in a state of expansion the fruit is nearly globular, as represented by figs. 30 and 31, plate 10." Unfortunately, the only specimen of these three which is still extant is that represented in figs. 30, 31 ; this is now broken, and is clearly a concretion and not a fruit.

The specimen figured by Bowerbank (pl. x, figs. 26, 27) does, however, appear to have been a true fruit as evidenced by the figures. In his diagnosis of the species he says " *Fruit* globular, smooth, with five lateral and one terminal scutiform plates, the latter somewhat umbonate " ; and in the description which follows, when comparing the fossils with cones of *Cupressus*, he says : " Our fossil is, in like manner, composed of five lateral, scutiform, scales or plates, but without umbones, fitting closely to a broad, angular base, as represented at fig. 31, plate 10 [the concretion], which is a view of the base of a fruit, with a small portion of the stalk (*a*) remaining attached to it. The five lateral plates do not extend to the apex of the fruit, which is formed by a sixth plate or scale, as seen at *a*, fig. 30, plate 10, and which, in this instance, is considerably more gibbous at about its centre than the lateral ones. . . .

" Figs. 26 and 27, plate 10, represent the largest specimen of this species which

I have yet seen. The whole of the lateral plates, with the terminal one remaining attached to them, appear to have separated spontaneously from the broad angular base of the fruit, . . . fig. 26, plate 10 . . . is a view of the interior of the fruit given in fig. 27, plate 10."

The diameter of this largest specimen as measured on the figures is 18·5 mm. Bowerbank's figures suggest very strongly that his interpretation of the specimen was wrong. It is apparently a five-valved capsule, gaping loculicidally, as evidenced by the septal ridge along the middle of the inner face of each valve in fig. 26, while in fig. 27 the large pentagonal area (*a*) is evidently the base and not an apical scale.

We cannot tell what the relationship of the fruit may have been, as no further information is available. But it is quite clear that there is no reason for referring it to the Cupressineae.

The third specimen (Bowerbank states), " although very much smaller, agrees perfectly in the number, form, and position of its plates, with fig. 27." As there are no figures of this specimen, we can say nothing about it.

Carpolithus curtus (Bowerbank)

1840. *Tricarpellites curtus* Bowerbank, p. 81, pl. xi, fig. 35.

The species is based on three specimens, none of which can now be traced. Bowerbank's diagnosis is as follows: " *Capsule* smooth, largest near the middle; breadth of the valves nearly equal to their length." He states that "The surface of the capsule is smooth and even. The average breadth of the valves in proportion to their length is as eleven to thirteen, . . . The seeds are broad and short in proportion to the valves, and the testa is reticulated." He states that he did not see the placenta. The length as measured on the figure is 7·25 mm., and the breadth, 7 mm.

It is probable that the " seeds " to which Bowerbank refers are really locule-casts, as in his descriptions of *Tricarpellites communis*, *Cupanoides*, etc., while the reticulated " testa " represents the inner part of the carpel wall as in *T. communis* (cf. p. 270) and other members of the Burseraceae. It is possible that the species should be referred to the Burseraceae, but the evidence is insufficient for satisfactory determination. The form of the seed or locule-cast, as depicted at (*b*) in Bowerbank's fig. 35, recalls *Protocommiphora europaea* (p. 273, Pl. X, figs. 1–7), but *P. europaea* is only two-loculed, whereas the species now under discussion was presumably three-loculed since Bowerbank refers it to his three-loculed genus *Tricarpellites* (1840, p. 76). We have therefore placed it in the form-genus *Carpolithus*, since Bowerbank's description and figures are insufficient to warrant any more definite determination, and the specimen has disappeared.

Carpolithus gracilis (Bowerbank)

1840. *Tricarpellites gracilis* Bowerbank, p. 82, pl. xi, figs. 37, 38.

By its association with the genus *Tricarpellites*, this species, like the preceding, was also presumably three-lobed, and perhaps three-loculed. The following is

Bowerbank's diagnosis: " *Capsule* smooth, or obsoletely striated longitudinally, largest towards the apex: base somewhat attenuated: length of the valves exceeding three times their greatest breadth." There were two specimens only; both were figured but have now disappeared. No seeds were seen. The length of the specimens (measured from the figures) was 10·5 to 11·5 mm.; the breadth, 4·5 to 5·25 mm.

The specimens were probably internal casts either of three-loculed fruits, or of one-loculed three-lobed fruits. There is no clue as to their true relationship. It is possible that a specimen collected at Minster by ourselves and described on p. 526 (Pl. XXXI, fig. 40) as *Carpolithus* sp. 33, should be identified with *C. gracilis*, with which it corresponds in shape, size, and number of lobes. But the evidence is inconclusive.

Carpolithus crassus (Bowerbank)

1840. *Leguminosites crassus* Bowerbank, p. 125, pl. xvii, figs. 3, 4.

Under the name *Leguminosites crassus* Bowerbank describes a single specimen, no longer extant, of which he figures two aspects. His diagnosis is as follows: " *Seed* oval, thickness nearly equal to its depth; depth from face to back exceeding three-fourths of its length: testa smooth." He gives the dimensions as eleven-fiftieths of an inch from side to side, thirteen-fiftieths from the face to the back, and sixteen-fiftieths of an inch in length. The specimen is said to be somewhat distorted.

Fig. 4 shows a large, circular depressed area, delimited from the rest of the seed by a circular groove. Bowerbank regarded this as a fracture in the testa exposing the cotyledon within, and he remarks that its surface was " covered by impressions of numerous minute vessels " which radiated from a deep depression on its surface.

The evidence of figure and description suggests, in our opinion, that this area with its diverging vessels was a chalazal scar.

The evidence is insufficient for the determination of the specimen, but it cannot be referred to Leguminosae. It may be an endocarp of one of the Lauraceae, the circular scar being the large chalaza of the seed within; but possibly it should be referred to the Tiliaceae or Sterculiaceae, and it may perhaps have been a seed from one of the fruits described on pp. 393, 397, although these seeds are somewhat smaller and more pointed than the present specimen, so far as our evidence goes. The seeds of many Sterculiaceae and Tiliaceae have a large chalazal scar with a central depression surrounded by fine radiating cells (cf. Pl. XX, fig. 18). In the absence of conclusive evidence, and of the specimen itself, we have been obliged to refer it to *Carpolithus*.

Carpolithus lentiformis (Bowerbank)

1840. *Leguminosites lentiformis* Bowerbank, p. 131, pl. xvii, figs. 19, 20.

The description of this species by Bowerbank was based on two specimens, of which he figured one only. Neither specimen is extant at the present time. His diagnosis is " *Seed* lentiform, radicle conspicuous: testa smooth, thick."

He further states that the seed figured had lost its testa and that there was " a slightly-depressed line running round the whole edge of the seed, indicating the line of separation of the cotyledons." In other words, the specimen figured was the internal cast of a seed, and may have shown on its surface indications of the two cotyledons. At the same time, experience has shown us that such appearances may be very deceptive and may more often indicate crumples or folds due to shrinkage.

The evidence is insufficient to justify Bowerbank's determination of a leguminous seed in a deposit almost devoid of Leguminosae, or to suggest the true affinities of the specimens.

Carpolithus monasteriensis n. sp.

PLATE XXX, figs. 6–8.

DIAGNOSIS.—Endocarp thick and woody, ovoid, six-loculed, syncarpous, each locule one-seeded ; locules elongate, narrowed at both ends, aligned longitudinally, four being placed in a ring and two outside the ring between the two pairs ; dehiscing by dorsal valves ? ; length, 10 mm. ; diameter, 7 mm. Seed with testa formed of elongate parallel-sided cells longitudinally aligned ; diameter, 1·25 to 2 mm.

HOLOTYPE.—V. 23164.

DESCRIPTION.—*Endocarp :* Ovoid, flatly ribbed externally with longitudinal strands of fibres in the furrows, syncarpous, six-loculed, each locule one-seeded. Locules elongate and tapering at both ends extending from top to bottom of the endocarp, roundly triangular in section, one angle being directed to the centre and the two others towards the periphery. The six locules are not all arranged in a ring, but four are so arranged at equal distances from the centre, the two others being further out and opposite to one another between pairs of the central four (Pl. XXX, fig. 7). The endocarp is thick, hard, and woody, and is formed entirely of closely compacted fibres which, although much twisted, have a general radial alignment. Around the locules are several concentric layers of fibres, the alignment of the fibres in the various layers being slightly different, but all being either horizontal or somewhat oblique. In transverse sections of the fruit these fibres are seen to pass outwards to the periphery along the angles of the locules as though they might form planes of weakness for the opening of dorsal valves. The locule-lining is formed of similar fine fibres longitudinally aligned. Length of fruit, 10 mm. ; diameter, 7 mm.

Seed : Similar to the locule in shape, tapering at both ends. The shape indicates that it must have been either anatropous or orthotropous, but information is not available to decide between these two possibilities. At one end the seed tapers to a narrow point and this probably represents the micropyle. The testa is formed of elongate parallel-sided cells with faceted or obliquely truncate ends, measuring 0·025 mm. in breadth and from 0·1 to 0·25 mm. in length. These cells are mostly longitudinally aligned, but towards the ends of the seed they become oblique. The diameter of fully developed seeds varies from 1·25 to 2 mm.

REMARKS.—One specimen from Minster. The specimen was perfect except that it was superficially worn so that in places the locule-casts were exposed or had even been sectioned. Except that there were six locule-casts nothing could be discerned from the exterior as to the character of the coats or the arrangement of the seeds. The fruit was therefore fractured, both transversely and longitudinally, exposing the general form and arrangement of the locules and the structure of the locule wall. In places, also, the testa was seen. Unfortunately, as the specimen was impregnated throughout with hard pyrites, the fracture only resulted in the partial separation and exposure of the successive coats of endocarp and testa, and no organs could be traced. Further fracture was not successful in revealing them, but it did show more clearly the testa and the locule-lining, also the complete shape of the locule.

Affinities.—The fossil has certain characters in common with two or three living families, but the differences in every case are too great to permit of its inclusion in any of these. Thus the fibrous structure of the carpel wall is somewhat similar to that found in some of the Anacardiaceae, but the form of the locule is different ; the apparent mode of dehiscence by throwing off lateral valves is not that of Anacardiaceae, and the locule-lining in the many-loculed Anacardiaceae is formed of interlocking digitate cells, not of longitudinal fibres ; also the cells of the testa are different. Some of the Cornaceae (*Mastixia*, *Davidia*, and certain fossil genera, cf. pp. 453-463) germinate by throwing off long valves from the dorsal surfaces of the locules, also the carpel wall is formed of intertwined fibres, but the fibres are much coarser and not close and compacted as are those of the fossil, and the locule-lining is unlike that of the species here described. Many species of *Symplocos* have endocarps of comparable size and shape, with locules of a like shape, and a somewhat similar testa, but the walls are not formed throughout of close compacted fibres, and germination does not take place by throwing off lateral valves. We cannot therefore refer the fossil to any of these families.

V. 23164 Holotype, figured Pl. XXX, figs. 6–8. A six-loculed fruit, now fractured to show the structure. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus thunbergioides n. sp.

Plate XXX, figs. 9–13.

Diagnosis.—Fruit ovoid, one-loculed, one-seeded, dehiscing into two valves ; pericarp thick, formed of close, fine parenchyma ; locule ovoid, placed obliquely near one end of the fruit, striate longitudinally, and transversely undulate ; length of fruit, 6·5 mm. ; breadth, 4·3 mm. ; thickness through both valves, 5 mm. ; length of locule-cast, 3·3 mm. ; diameter, 2·3 mm. Seed longitudinally striate.

Holotype.—V. 23165.

Description.—Three specimens appear to belong to this species. The most complete (Pl. XXX, figs. 9–11) is an ovoid fruit with a thick pericarp formed of fine close-grained parenchyma. The ovoid locule lies obliquely across the fruit nearer to one end than to the other. The carpel evidently partially dehisced into two valves because it had begun to gape around the locule, and in this area the surfaces are smooth and finished, but towards the solid end of the fruit there is no indication of such dehiscence, and when separated, one valve broke irregularly from the other. The ovoid locule-cast shows a surface finely striate longitudinally, the striae radiating from two opposite poles, one pole being slightly raised and the other depressed. The surface is also thrown into undulations which give the effect of a network. The seed is longitudinally striate.

The two other specimens are detached locule-casts (Pl. XXX, figs. 12, 13). They are larger than the one just described. The characters both of the surface of the locule-cast and of the testa are identical in all three specimens, except that the two now under consideration have a flattened area (of attachment ?) at one end (Pl. XXX, fig. 13). Length of fruit, 6·5 mm. ; breadth, 4·3 mm. ; diameter through the two valves, 5 mm. ; length of locule-cast, 3·3 mm. ; breadth, 2·3 mm. ; length of the isolated locule-casts, 4·5 and 5·6 mm. respectively ; breadth, 4·16 and 4·5 mm.

REMARKS.—The form and ornamentation of these locule-casts is peculiar. The only one-loculed, one-seeded fruit which breaks into two woody valves and might present a somewhat comparable appearance is *Thunbergia* belonging to the Acanthaceae ; yet even in this the resemblance is merely superficial, since in the fossil the corrugated entity is the locule-cast, the testa of the seed being smooth, whereas in *Thunbergia* it is the testa of the seed itself that is corrugated.

V. 23165 Holotype, figured Pl. XXX, figs. 9–11. A carpel, fractured loculicidally, showing the small locule-cast within. *Reid & Chandler Coll.*, Minster, 1929.

V. 23166 Figured Pl. XXX, fig. 12. A locule-cast, broken on one side to show the seed within. *D. J. Jenkins Coll.*, Herne Bay.

V. 23167 Figured Pl. XXX, fig. 13. A locule-cast. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus lignosus n. sp.

PLATE XXX, figs. 14–17.

DIAGNOSIS.—Fruit syncarpous, five-loculed, with one pendulous seed in each locule, truncate-ovoid, dehiscing septicidally into cocci which then split loculicidally ; locules tangentially compressed ; endocarp columnar in section ; placentation axile. Length, 13 mm. ; diameter, 13 mm. Seed sub-ovate in outline, narrowly lenticular in transverse section ; testa formed of polygonal cells ; tegmen of elongate cells ; anatropous ?, micropyle terminal on the ventral margin. Length, 12·5 mm. ; breadth, 6 mm.

HOLOTYPE.—V. 23168.

DESCRIPTION.—*Fruit :* Woody, probably inferior, syncarpous, five-loculed, with one seed in each locule, truncate-ovoid, five-partite at the apex where there is a large deep depression ; dehiscing both septicidally and loculicidally ; septicidal dehiscence causes it to separate into cocci (cf. Pl. XXX, fig. 16, representing two such cocci), loculicidal dehiscence is shown by a longitudinal crack in all but one of the carpels through which the hard locule-casts protrude (Pl. XXX, figs. 14, 15). The locules extend from base to apex of the fruit and are narrowly oval in transverse section, being compressed tangentially. Exocarp thick, especially over the dorsal surface and in the angles between the locules, woody but loose-textured, with irregular large longitudinal cavities which seem to have been filled with softer tissue now represented by a little decayed carbonaceous matter. This woody coat is followed by a thin coat (possibly part of the endocarp) formed of a few layers of irregular polygonal cells. Endocarp thick, hard, formed of many layers of small polygonal cells which have a columnar arrangement in section ; it becomes thinner both towards the periphery and towards the axis, and at the periphery shows loculicidal dehiscence ; at the axis a large canal lies within its thickness which runs along the straight inner margin of the locule nearly to the apex, where it passes into the locule. This must be the funicular canal. The placentation must therefore be axile and the seed pendulous from near the apex of the fruit. Length of fruit, 13 mm. ; diameter, 13 mm.

Seed : Sub-ovate in outline, with a nearly straight ventral margin and convex dorsal margin, narrowly lenticular in cross-section. The testa is formed of two coats : the outer is composed of regular hexagonal or polygonal cells, the casts of which have inflated ends so that the surface of the seed was probably covered with close, small, low tubercles ; the inner coat (tegmen ?) is formed of slightly curved, elongate, polygonal cells with faceted ends, about five times as long as they are broad, aligned for the most part transversely, but converging towards a point at one end of the ventral margin, which probably therefore represents the micropyle. That the hilum was near the same point is shown by the seed being pendulous. Therefore it was almost certainly anatropous, and probably had a ventral raphe. Length of seed, 12·5 mm. ; dorsi-ventral breadth, 6 mm.

REMARKS.—One specimen, which, when we first saw it, was in three fragments. Two of these were separate cocci, one being imperfect as it had lost a portion of one side. When pieced together, the circle of cocci showed a gap adjacent to the broken side of the coccus. The breadth of this coccus suggested that it perhaps might represent more than one carpel, but there was no outward indication that it did so. A section proved that it was merely one wide carpel, hence that the number of carpels in the fruit was five. As we had no evidence on which to base any determination of the fruit, we sectioned the perfect coccus transversely, thus exposing the cross-section of the locule with the thick columnar wall of the endocarp. We were further able to chip away part of the septum from one lateral face, and then part of the columnar endocarp from the same face, so as to expose the tegmen, and in a very small degree, the testa, but we still could get no clue as to the nature of the placentation, or the arrangement of the organs in fruit and seed. We therefore cut away a large part of the carpel wall, including the remaining septum, from the imperfect coccus, and chipped away the columnar endocarp over a considerable portion of its lateral surface. This showed the form of the seed, and the structure of the testa and tegmen, more clearly than we had seen it before. As neither of the detached cocci showed the protruding longitudinal ridges of pyrites seen on the large fragment, we sectioned transversely one of the three united cocci with the result that not only was it fractured but it also came free. The ridges proved to be the locule-casts protruding where the columnar endocarp thinned at the dorsal margin to allow of loculicidal dehiscence. The endocarp also thinned at the inner angle where it formed a wall around the funicular canal. This canal was shown both in transverse and longitudinal sections and was further very clearly seen to enter the locule at a point on the ventral margin near its wider end. This evidence proved that the funicle must have arisen from a receptacle at the narrow end of the fruit, which therefore must be the base, and after passing along the axis entered the locule near the apex, so that the seed must have been pendulous from the apex of the fruit.

Affinities.—If the above observations are correct we must look for this fruit among five-loculed syncarpous fruits having both septicidal and loculicidal dehiscence, with axile placentation, and one pendulous anatropous seed in each locule. Excepting the combination of both septicidal and loculicidal dehiscence, a character on which we do not lay over much stress, because septicidal dehiscence might conceivably be due to the effect of decay and fossilization on sutures only partially fused during life, the only possible families in which to seek alliance are Linaceae, Meliaceae, Rhizophoraceae, Simarubaceae, Ternstroemiaceae, and Tiliaceae. Of these families, the only ones in which the form of carpel, locule, and seed are at all comparable with those of the fossil are Linaceae and Meliaceae. In both these families the carpel wall is greatly thickened in the angles between the locules, the locules themselves being tangentially compressed, and the seed flattened. We have not been able to make microscopic comparison with many genera showing similar forms of fruit in either of these families. In Linaceae *Hugonia* and *Roucheria* suggest themselves as possible allies. In Meliaceae, *Sandoricum* and *Munronia*. Of these genera we have only been able to make a microscopic study of *Hugonia*, which does not suggest in its size or in the cell-structure of the fruit wall (especially in the absence of a columnar endocarp) any close alliance. In form of seed, and structure of testa, the fossil shows some resemblance to the seeds of *Linum* and *Hugonia*, the only ones with which we have been able to make microscopic comparison in this family. Of Meliaceae, the only fruit of at all comparable character which we have been able to study is *Azadirachta indica* A. Juss. It also, except in the general form of fruit and locule and in placentation, shows no close relationship, and the cells of the testa are unlike. We cannot, therefore, determine the relationship of this species.

V. 23168 Holotype, figured Pl. XXX, figs. 14–17. A fruit, now in fragments. V. 23168. Three cocci, one detached and fractured transversely. V. 23168*a*. A detached coccus, fractured transversely (cf. fig. 16). V. 23168*b*. A seed, dissected out of an imperfect detached coccus (cf. fig. 17). *Bowerbank Coll.*, Sheppey.

Carpolithus ebenaceoides n. sp.

Plate XXX, fig. 18.

Diagnosis.—Seed sub-ovate in outline, slightly compressed laterally, raphe near the margin ; testa formed of an outer coat of large cells, and middle coat of elongate parallel-sided cells ; and an inner coat of minute polygonal cells ; length, 10·5 mm. ; breadth, 7·3 mm.

Holotype.—V. 23169.

Description.—*Seed :* Anatropous, sub-ovate in outline, with one margin more convex than the other, rather pointed at one end and blunt at the other, somewhat laterally compressed, sharply angled on the less convex margin and rounded on the other. Testa showing an outer coat of large cells ; at or near the pointed end these are elongate and arranged in sinuous, approximately longitudinal lines, or in a slightly tortuous manner. At the blunt end the cells are smaller and shorter, being nearly equiaxial. Within this coat follows a layer of elongate parallel-sided cells which taper at the ends and are longitudinally aligned, beneath which is a smooth shining coat formed of minute polygonal cells of irregular shape, very difficult to see. Associated with the outer coat is a thick longitudinal strand of fibres, the raphe (Pl. XXX, fig. 18), which lies near the more convex margin of the seed. Length of seed, 10·5 mm. ; maximum breadth, 7·3 mm.

Remarks.—One specimen from Minster. It is the internal cast of a seed with portions of the pyritized testa adhering to it. The seed has the shape and size of those of some Sapotaceae, but the coats are not typical of Sapotaceae and we have not been able to distinguish the system of branching fibres formed by the raphe which is so characteristic of that family (cf. Pl. XXVI, figs. 37, 38, Pl. XXVII, figs. 1, 2). The large cells with tortuous and sinuous arrangement suggest a possible relationship with the Ebenaceae. The only member of this family with which we have been able to make close comparison is *Diospyros*, but the fossil differs from the seeds of *Diospyros* in being somewhat inflated, in not having a straight ventral margin, and in the much less tortuous arrangement of the large cells. The cells of the innermost coat have some resemblance to those of the testa in Icacinaceae, but the seed is not very typical of the family in shape, and there are more coats in the testa than normally occur in Icacinaceae.

V. 23169 Holotype, figured Pl. XXX, fig. 18. A seed, with remains of testa. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus quadripartitus n. sp.

Plate XXX, figs. 19–21.

Diagnosis.—Fruit oblate-spheroidal, syncarpous, four-loculed, with one seed in each locule, dehiscing first into halves along a plane parallel to the narrow faces of the locules, then into four cocci along a plane parallel to the broad faces of the locules ; pericarp extremely thick, formed of large prismatic cells ; locules elongate, narrow-oval in transverse section, close together ; length of fruit, 7 mm. ; diameter, 8 mm.

Holotype.—V. 23170.

Description.—*Fruit :* Oblate-spheroidal, syncarpous, with a thick fibrous axis, four-loculed, four-seeded, the locules small, elongate, rounded at the ends, narrow-oval in transverse section, clustered close around the axis, with which they communicate by small narrow apertures which must represent the funicular canals. The placentation, consequently, would be axile. Dehiscence takes place primarily into two two-loculed hemispheres, the flat faces of which form the primary plane of dehiscence. Next the hemispheres break in half to form four cocci, the planes of fracture being those of secondary dehiscence. The locules are placed symmetrically with regard to these two planes, their narrower faces abutting against the primary planes and their broader faces against the secondary planes. In proportion to the size of the locules the carpel walls are exceptionally thick on the dorsal side (cf. Pl. XXX, figs. 20, 21, in which the complete diameter of the locule is seen), but between the locules they are very thin. They are formed of large prismatic cells which are radially aligned and longer near the axis than at the periphery. These cells may measure 0·33 mm. by 0·1 mm. near the axis, 0·2 mm. by 0·15 mm. near the periphery, and 0·1 mm. in diameter on the worn surface, where many are pentagonal as seen in transverse section. The abutting faces of the four segments show the remains of a thin coat formed of fusiform or polygonal cells with a generally oblique, but very irregular and tortuous alignment ; we could not measure the exact size of these cells. Immediately around the locules is a thin compact carbonaceous coat, the cells of which are too decayed to be measured, but the impression of its inner surface on the locule-casts shows very delicate elongate cells tapering at both ends and measuring 0·008 mm. in cross-section. Length of fruit, 7 mm. ; diameter, 8 mm.

Seed : Similar in shape to the locule. Although the impression of the testa was seen in one small patch on the seed-cast, the form of its cells could not be discerned.

Remarks and Affinities.—One specimen found by ourselves at Minster in 1929. The dehiscence into cocci having thick walls over the outer faces of the locules and very thin walls over their inner faces, suggests that germination took place by the rupture, either general or loculicidal, of these thin walls. The breaking into four cocci suggests possible alliance with Verbenaceae or Boraginaceae, but these do not split loculicidally, and relationship would therefore appear to be excluded. We do not know what other relationship to suggest.

V. 23170 Holotype, figured Pl. XXX, figs. 19–21. A four-partite fruit, now fractured to show the locule-casts and carpel wall. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus bignoniformis n. sp.

Plate XXX, figs. 22, 23.

Diagnosis.—Locule-cast that of a large inflated pod, bisymmetric about a plane passing through a marginal groove which becomes obscure at the two ends ; length of fruit, 112 mm. ; dorsi-ventral diameter, 48 mm. ; thickness, 36 mm. Seeds ? numerous, semi-oval ; length, 65 to 79 mm. ; breadth, 29 mm.

Holotype.—A 1474 in the Canterbury Museum.

Description.—This specimen appears to be the calcareous locule-cast of a large inflated pod. It is bisymmetric about a plane passing through a marginal groove which is carried along both the long margins, but becomes a little obscure at the two ends. Whether this is due to a true deviation of its course or to some accidental damage cannot be ascertained. It is impossible to tell whether any cell-structure has been preserved on the surface of the cast as the specimen is very heavily coated with oil and mastic. But we do not think, from the obscure evidence where this coating is thinner or has been chipped, that any cells are preserved. On one side two grooves are seen bounding semi-oval areas (Pl. XXX, fig. 23). The approximately straight edges of these areas abut against the marginal rim of the cast and the convex edges are directed towards one another on the middle of the face. The areas thus delimited are comparable, but not identical, in size and shape. There are other lines passing in various directions, but none so conspicuous nor so definite as these. Length of cast, 112 mm.; dorsi-ventral diameter, 48 mm.; thickness, 36 mm.

The specimen was lent to the British Museum for the purpose of study by Mr. H. T. Mead, the curator of the Royal Museum, Canterbury. We wish to express our thanks to him for giving us this opportunity of examining it. Mr. Mead writes that he has "endeavoured to trace some particulars concerning this specimen. The number A 1474 I have found in a list made by Dr. James Reid in 1873. The entry reads, 'A 1474—Large elongated ovoid body resembling a pod. Sheppey.' From a study of the Synopsis of the Museum published in 1826, I am of opinion that the specimen was in the original collection when the museum opened in the year 1825."

The "Synopsis of the Museum" alluded to above, which was also lent by Mr. Mead, has no definite reference to this particular fossil, but in relation to the Sheppey vegetable fossils states generally that "to ensure their preservation, a boiling in oil and a coating of mastic varnish are necessary." It is to this treatment that we owe, in all probability, the hundred years preservation of this fossil in the museum, as well as our present inability to examine the nature of its surface. It appears to be one of the very few survivors of the Crow Collection.

The form of the fossil with its encircling marginal groove, also the fact that where chipped it shows no cells within, indicates that it represents the locule-cast of some kind of fruit, and that the fruit was almost certainly a pod. Pods of this size, although not so commonly of this form, are found in various families, one of the most obvious being the Leguminosae. But we think that reference to this family is quite precluded because, almost certainly, an internal cast would show indications of the hollows in which the seeds lay. The family which appears to us to offer the most likely relationship is the Bignoniaceae. In this family many genera have pods with locules quite comparable in size and form with the fossil. If the delimited areas mentioned above are not merely accidental, they may represent the impressions of large seeds left upon the locule wall, the seeds being attached as in the tribe Bignoneae to lateral placentas, which may be represented by the lateral grooves. In making this suggestion we do not in the least imply that the evidence is sufficient to place the specimen definitely in the family Bignoniaceae. That is very far from being the case.

Carpolithus ranunculoides n. sp.

Plate XXX, figs. 24, 25.

Diagnosis.—Fruit an achene, sub-ovate in outline, flattened perpendicularly to the plane of bisymmetry, slightly convex on the ventral, and highly convex on the dorsal margin, with a thick flat style at the top, and attachment at the base, of the ventral margin; exocarp formed of parenchyma with a few embedded strands of fibres; endocarp formed of parenchyma and lined with layers of fibre which curve from attachment to style. Length, 6·5 mm. Seed with testa formed externally of elongate secreting cells, and internally finely striate longitudinally.

HOLOTYPE.—V. 23171.

DESCRIPTION.—*Fruit:* A flattened achene almost certainly borne on a head or spike, sub-ovate in outline, slightly convex on the ventral margin and more highly convex on the dorsal, strongly margined ventrally by a broad thick band of fibres which passes up into the thick flat style and may have formed a wing or awn, bisymmetric about a plane passing through this rib and the median dorsal line, but apparently not dehiscing along this plane. Although the fruit is somewhat compressed laterally, yet the lateral faces are inflated. The attachment and style are terminal on the ventral margin at opposite ends; the style is imperfect because the stone is broken across. Exocarp formed of rather coarse parenchyma with a few strands of fibres within it. Endocarp formed of two layers of parenchyma, the inner finer than the outer, and a lining of two or three smooth layers of close fibres which form a smooth shining surface to the locule, the cells converging to the attachment and style. The testa is fairly thick, formed of rather large elongate cells containing some black substance. It can be seen only in a few very small patches around the internal cast of the seed, which itself is exposed in one small area and shows extremely fine longitudinal striae. Length of fruit, 6·5 mm.

REMARKS.—One specimen was found in a small block of sandy limestone from Assington, Suffolk. The same block contained the seed of *Vitis minuta* (p. 381) and *Iodes* sp. (p. 330). The block shattered so that the locule-cast came away from the carpel over the greater part of one face, but remained attached to the carpel and embedded with it in the rock on the counterpart. The shattering caused a ragged split through the ventral rib including the attachment and style. Unfortunately the distal end of the style is wanting, the rock being broken, so that there is no means of telling its original shape or length. For the rest, the carpel wall has stripped irregularly from the locule-cast, thus fortunately exposing successive coats in irregular section. In part, too, it has carried away with it the testa, exposing the seed-cast with its finely striate surface. The testa, thus torn, has disappeared, only remaining as a narrow rim beneath the broken edges of the locule-cast on the small fragment. On the outer surface of this locule-cast are the impressions of the cells lining the locule. Unfortunately, the outer surface of the fruit everywhere merges into the rock except in one part over the dorsal margin, where a delicate line seems to delimit it for a short distance.

We think there can be no doubt that the fruit was an achene, and its shape and the manner of attachment suggest that it was one of two or more fruitlets which may have formed a head or spike. Its most distinctive feature seems to be the thick ventral rib prolonged into a conspicuous style, and probably produced into an apical awn, as it is very thick even where broken. Apical awns or wings are not very uncommon.

In some of its characters: the stiff awn-like style, the structure of the pericarp, and the general shape, the fossil somewhat resembles the fruits of *Ranunculus;* but it is indehiscent, whereas the fruits of *Ranunculus* dehisce into symmetrical halves; again, the fossil is much larger than the achenes of *Ranunculus,* and so far as we have been able to investigate, no member of the Ranunculaceae has a similar tegmen.

V. 23171 Holotype, figured Pl. XXX, figs. 24, 25. An internal cast of a fruit, and two counterpart fragments with remains of carpellary coats, preserved in sandy limestone. *John Brown Coll.,* Assington, Suffolk.

Carpolithus semencorrugatus n. sp.

Plate XXX, figs. 26–32.

Diagnosis.—Endocarp one-loculed, one-seeded, ovoid with a deep longitudinal infold obscured externally by an infilling of tissue; locule lunate in cross-section, bisymmetric about a median vertical plane through the infold, surface irregularly ridged and furrowed; length of endocarp, 7·75 mm.; diameter, 5·3 mm. Seed anatropous, with micropyle at the pointed end, hollowed on the ventral face, lunate in cross-section, boldly sculptured with large ridges and furrows.

Holotype.—V. 23172.

Description.—*Endocarp:* One-loculed, one-seeded, ovoid and more or less smooth externally (Pl. XXX, fig. 26), but with a broad, deep, longitudinal infold or thickening internally on the ventral face which projects into the locule as a conspicuous, rounded, longitudinal ridge, making the locule-cast irregularly lunate in cross-section (Pl. XXX, fig. 27). The carpel wall is formed of parenchyma with cells about 0·05 mm. in diameter, but on its external (worn) surface are thick strands of fibres (Pl. XXX, fig. 26). The infold or internal ridge is formed of coarse parenchyma. The locule is lined by small equiaxial cells. In form it is remarkably different from the fruit: approximately bisymmetric about a median plane passing vertically through the longitudinal ridge, sharply pointed at the apex, irregularly lunate in cross-section, with a few irregular, broad, longitudinal ridges and grooves on its surface, and nodular at its margins (Pl. XXX, figs. 27, 28). Length of endocarp (incomplete), 7·75 mm.; breadth, 5·3 mm.; thickness, 5·3 mm.

Seed: Conforming in shape to the locule-cast (Pl. XXX, figs. 29–32), micropyle at the pointed end, anatropous, with the chalaza at the rounded end as indicated by the alignment of the cells. Testa thin, formed externally of cells, 0·017 mm. in diameter, which produce a smooth surface, and internally of very irregular angular cells, 0·025 to 0·05 mm. in diameter. Length of seed, 6·7 mm.; breadth, 5 mm.; thickness, 4·5 mm.

Remarks.—Two specimens. The external appearance of the most perfect specimen suggested relationship with the Juglandaceae on account of its shape, its pointed apex, and its coat formed of parenchyma and fibres. During our examination of this specimen the thick tissue filling the ventral groove partly came away showing that on this side the locule-cast was lobed, which suggested, at first sight, an even closer resemblance to one of the Juglandaceae, for example a species of

Carya. It was consequently necessary to ascertain what was the true form of the locule and seed. This was done by carefully removing the endocarp, thereby showing that the locule-cast and seed were lobed on one side only. Since, therefore, the form of locule and seed forbid the inclusion of this species in the Juglandaceae, we have no idea as to its true relationship. We have been unable to find any fruits or seeds comparable in character. Some of the Menispermaceae suggest a possible relationship, but we have seen nothing really like the fossils, and the structure of the carpel is unlike that found in this family.

V. 23172 Holotype, figured Pl. XXX, figs. 26–32. A seed, with remains of endocarp (now in fragments).
V. 23173 A second seed.
Both are from the Bowerbank Coll., Sheppey.

Carpolithus olacaceoides n. sp.

Plate XXX, fig. 33.

Diagnosis.—Endocarp one-celled, one-seeded; outer coat of hexagonal cells with longitudinal strands of fibres on its inner face which branch and anastomose towards the apex; a longitudinal ridge at the apex is associated with a strand of fibres (funicle ? or for dehiscence ?); length, 19 mm.; diameter, 13·5 mm.

Holotype.—V. 23174.

Description.—*Endocarp:* Obovoid, tapering abruptly to a narrow base where there is a circular scar, one-celled, one-seeded. The only coat preserved as more than an impression is the outer one. This is thin and formed throughout of parenchyma, the cells being uniformly hexagonal and closely packed; those forming the outer surface are 0·025 mm. in diameter; those forming the inner surface 0·05 mm. in diameter, hence the outer surface is smoother than the inner. The coat, although thin, must have been hard as the specimen has preserved its shape perfectly. Beneath this coat there lies a system of longitudinal strands of fibres; these diverge upwards from the narrow base, and towards the apex seem to have branched and anastomosed. Immediately around the base, where for a short distance the outer coat has been chipped away, they form rather conspicuous ribs, and here the impressions of the actual fibres can be seen. Higher up over the middle of the fruit, except in a few small patches showing similar impressions, they are entirely masked by the impressions of the cells of the outer coat, but their direction is indicated by the folds or ripples which they produce. From these it appears that they were undivided strands for the greater part of their course, but towards the apex branched and anastomosed, probably forming a coarse network, although the greater part of this is hidden. At the apex the remains of a conspicuous longitudinal ridge are associated with the outer coat, and beneath the ridge at its lower end is a thick strand of fibres (funicle or marginal fibres of valves). Length of endocarp, 19 mm.; diameter, 13·5 mm.

Seed: Similar in form to the endocarp. Testa formed of polygonal cells 0·05 to 0·075 mm. in diameter. Traces of fibro-vascular bundles can be seen on its surface.

Remarks.—One specimen, sectioned in the hope of obtaining more information. It proved to be an endocarp containing a single seed devoid of internal structure. The form and structure of the endocarp suggest possible relationship with the Olacaceae, but the evidence is too obscure to admit of certain determination.

V. 23174 Holotype, figured Pl. XXX, fig. 33. An endocarp fractured to show the structure and the seed. *Bowerbank Coll.*, Sheppey.

Carpolithus Stonei n. sp.

Plate XXX, figs. 34–37.

Diagnosis.—Fruit ovoid, with thin sharp angles marking the junctions and midribs of the carpels ; five-carpelled, syncarpous, one-loculed ? ; pericarp splitting into five longitudinal valves ; outer coat thick, inner coat thin. Length, 24 mm. ; diameter, 11 mm.

Holotype.—V. 6467.

Description.—*Fruit :* Syncarpous, five-carpelled, one-loculed (?), ovoid, with ten sharp angles which mark the midribs and margins of the carpels (Pl. XXX, figs. 34, 36). Dehiscence seems to have been valvular, the thick pericarp (or exocarp ?) splitting into five valves. One of these has become detached (Pl. XXX, figs. 35, 37) carrying with it the thin wall of the endocarp (?) (Pl. XXX, fig. 35). The width of the valve embraces two of the flat faces, the median ridge between these faces probably marking the midrib of the carpel. The carpel wall is too decayed and impregnated with mineral matter to permit of description. The outside integument (pericarp or exocarp) is thick, the inner integument (or endocarp ?) is thin. The free edges of the valves are smooth and finished, and show remains of a longitudinal strand of fibres (doubtless associated with dehiscence), and of a layer of large tortuous cells which seem to have covered the free edges of the valves. Length of fruit, 24 mm. ; diameter, 11 mm.

Remarks.—The specimen is silicified and highly impregnated with iron, and is much decayed, broken, and worn, so that the cells of which it is composed are almost entirely obliterated. We compared it with various fruits which are markedly angular, such as *Halesia*, and some of the Combretaceae, but have been unable to determine its relationship.

V. 6467 Holotype, figured Pl. XXX, figs. 34–37. A five-carpelled fruit with valvular dehiscence, one valve being detached. *Collected by Mr. Stone of Watford*, Watford Heath.

Carpolithus Bowerbanki n. sp.

Plate XXX, figs. 38–41.

Diagnosis.—Fruit ovoid, syncarpous (number of locules uncertain), seeds numerous, placentation axile, pericarp fibrous ; length, 24 mm. ; diameter, 18 mm. Seed semi-obovate in profile, roundly triangular in cross-section, anatropous, hilum and micropyle at the narrow end, raphe on the ventral margin ; testa formed of an outer coat, 0·2 mm. thick in parts, regularly tubercled, the tubercles hemispherical and an inner coat of elongate cells with longitudinal alignment and columnar arrangement in section. Length of seed, 9·5 mm. ; dorsi-ventral breadth, 5 mm. ; width of dorsal margin, 5·5 mm.

HOLOTYPE.—V. 23175.

DESCRIPTION.—*Fruit:* Ovoid, syncarpous, number of locules uncertain, possibly one only, many-seeded, seeds attached to the free end of the axis near the middle of the cavity, carpel wall fibrous, the fibres diverging obliquely from longitudinal strands which represent either the sutures or the median lines of carpels ; we do not know which. Length of fruit, 24 mm. ; diameter, 18 mm.

Seed: Semi-obovate in outline, roundly triangular in section, anatropous, with a ventral angle along which the raphe runs, the hilum and micropyle being at the narrower proximal end of the ventral angle, and the small black circular chalaza at the broader distal end. Testa tubercled externally with close-set, conspicuous, almost hemispherical tubercles, 0·075 mm. in diameter (Pl. XXX, fig. 40). The outer coat is formed of several layers of coarse parenchyma, the cells becoming smaller towards the interior ; the inner surface of this coat is finely tessellated. In parts the coat measures 0·2 mm. in thickness. Within, and usually separated from the outer coat by a layer of pyrites, is a coat of close elongate cells which in impression give a finely longitudinally striate surface and in section show a columnar arrangement ; its inner surface is formed of cells 0·02 mm. in diameter. The tegmen is formed of square or rectangular cells, 0·075 to 0·125 mm. in diameter, which are aligned transversely so as to give a ringed effect. Length of seed, 9·5 mm. ; breadth across the dorsal surface, 5·5 mm. ; breadth dorsi-ventrally, 5 mm.

REMARKS.—One fruit, broken in two before it came to us (Pl. XXX, figs. 38, 39). After being photographed it was further broken, and then revealed the mode of placentation and several perfect seeds (Pl. XXX, figs. 40, 41).

The outstanding characters of this fruit are the (probably) free central placentation, the shape and size of the seeds, and the highly tubercled testa. Among fruits with this type of placentation we have found none with seeds having similar tubercles ; they occur in some of the curvembryonic seeds, but among anatropous seeds they are very rare. We have found them in *Thomasia* (Sterculiaceae), but the shape of seed is different ; also the fruit is a loculicidal capsule with three to five locules and few seeds. We have also found seeds of comparable size, shape, and structure, and with somewhat similar tubercles, although much less conspicuous and less hemispherical, in *Acanthostachys* (Bromeliaceae) ; but a study of the seed-coats in this genus shows that they do not agree with those of the fossil, and we do not think there is any real relationship. Members of the family Melastomaceae also have hemispherical tubercles and somewhat similarly shaped seeds, but they are much smaller. We have been unable to determine the specimen.

V. 23175 Holotype, figured Pl. XXX, figs. 38–41. A fruit, fractured to show structure and seeds. One seed is figured (fig. 40) to show the external surface and another (fig. 41) to show the seed-cast and tegmen. *Bowerbank Coll.*, Sheppey.

Carpolithus nervosus n. sp.

PLATE XXXI, figs. 1–6.

1879. *Bauhinia primigenia* Ettingshausen (pars), p. 396.

DIAGNOSIS.—Fruit sub-globular (frequently compressed), one-celled, one-seeded, style and attachment at opposite ends, bisymmetric about a plane passing through a longitudinal strand of fibres lying in a groove ; pericarp formed of an outer coat of parenchyma, and an inner coat of transverse fibres ; length from 17 to 27 mm. ; diameter, 13 to 20 mm. Seed globular, semi-anatropous, the raphe branching to form eight to ten fibrous arcs between hilum and chalaza, which cover from one-third to one-half the equatorial circumference and are embedded in the parenchyma of the testa ; diameter of fully developed seed, 15 mm.

HOLOTYPE.—V. 23176.

DESCRIPTION.—*Fruit :* Globular or sub-globular when not distorted, but usually more or less compressed and sometimes with the seed twisted in the locule. Style and attachment at opposite ends (Pl. XXXI, figs. 1–3) ; passing through them is a strand of fibres lying in a groove which completely encircles the fruit and corresponds with a ridge on the locule-cast (cf. Pl. XXXI, fig. 6, ridge seen on the right above a crack). In undistorted specimens this ridge and groove mark a plane of bisymmetry, probably a suture. Locule of the same globular form as the fruit. Pericarp from 1·1 to 1·5 mm. thick ; the outer coat is formed of parenchyma, the cells, as seen in transverse sections of the fruit, being aligned radially, but not so closely compacted or regularly aligned as to present a columnar appearance. The outer surface of the pericarp (as preserved) is smooth except that it is covered by scattered circular pits 0·7 mm. in diameter. We are uncertain whether these are structural or the result of decay either before or after fossilization. Within this coat is one formed of fibres more than one layer thick. In the inner layers the fibres are aligned transversely and form a series of concentric rings around the style and attachment (Pl. XXXI, figs. 4–6). Exterior to these transverse layers there must have been others differently aligned, as in places there are criss-cross or tortuous impressions. The measurements of seven specimens are as follows : (1) Holotype, length, 23 mm. ; greatest diameter, 20 mm. ; least diameter, 13 mm. (2) A well-developed globular fruit, 17 mm. all diameters. (3) Length, 20 mm. ; greatest diameter, 18 mm. ; least diameter, 16 mm. (4) Length, 27 mm. ; greatest diameter, 20 mm. ; least diameter, 13 mm. (5) Broken and distorted specimen, length, 15 mm. ; greatest diameter, 18 mm. ; least diameter, 10 mm. (6) Locule-cast, length, 20 mm. ; greatest diameter, 18 mm. ; least diameter, 9 mm. (7) Length, 25 mm. ; greatest diameter, 21 mm. ; least diameter, 12 mm.

Seed : Globular when fully developed (frequently distorted and collapsed), semi-anatropous, the hilum and micropyle (marked by a conspicuous prominence) lying close to one end of the locule and the chalaza (marked by a slight depression) lying about half-way between the hilum and the opposite extremity of the seed, also (in undistorted specimens, in which the seed is globular and not displaced), lying in the plane of symmetry of the fruit (that which passes through the groove already described). Between the hilum and chalaza the raphe forms a remarkable series of eight or ten fibrous arcs symmetrically placed with regard to a median strand which directly connects the two organs (Pl. XXXI, figs. 1, 5). This system of fibres is confined to the ventral face of the seeds and occupies from one-third to one-half of the circumference. The fibres are embedded in the parenchyma of the testa, the cells of which measure about 0·05 mm. in diameter. The seeds when distorted or not fully developed tend to be longitudinally crumpled. They vary greatly in size and form, according to the degree of development and distortion. Diameter of a fully developed globular seed, 15 mm.

REMARKS.—Eleven specimens, all from Sheppey; several are in a bad state of preservation. Two specimens (Pl. XXXI, figs. 4–6) were in bottles labelled "*Bauhinia primigenia*" by Ettingshausen. One of these bottles also contained a specimen belonging to the Icacinaceae and another belonging to the Sapotaceae. That the species does not belong to *Bauhinia* or to any other of the Leguminosae is shown beyond a doubt by the structure of the pericarp and seed. We have been quite unable to trace the relationship of this beautiful species, although we have sought for it in many families.

V. 23176 Holotype, figured Pl. XXXI, figs. 1–3. A fruit, with carpel wall (now detached and broken).
V. 23177 Figured Pl. XXXI, fig. 4. Another fruit, with wall much broken and worn, labelled by Ettingshausen "*Bauhinia primigenia*."
V. 23178 Figured Pl. XXXI, figs. 5, 6. Another much abraded fruit, broken and distorted, labelled by Ettingshausen "*Bauhinia primigenia*."
The above are from the Bowerbank Coll., Sheppey.
V. 23179 A fruit with part of the endocarp remaining. The specimen is much cracked, and the cracks have been filled with pyrites which forms an irregular network on the surface. *Toulmin Smith Coll.*, Sheppey.
V. 23180 A similar specimen, broken and distorted. *Toulmin Smith Coll.*, Sheppey.
V. 23181 Six specimens in various stages of abrasion. *Bowerbank Coll.*, Sheppey.

Carpolithus scalariformis n. sp.

PLATE XXXI, figs. 7–14.

DIAGNOSIS.—Fruit elongate (length unknown), bipartite, syncarpous, dehiscing septicidally into two many-seeded valves, the seeds arranged in two rows in each valve, valves hemispherical in section; placentation probably parietal and seeds anatropous (but possibly axile and seeds orthotropous), pericarp formed of parenchyma with cells 0·05 mm. in diameter; seeds lying in pockets lined with transversely aligned cells; diameter of fruit, 5 mm. Seed sub-ovate with one margin nearly straight and one convex, micropyle at the narrow end turned away from the axis of the fruit, raphe ? on the straight margin turned towards the septum; length of seed, 1·4 mm.; greatest diameter, 1 mm.; least diameter, 0·5 mm.

HOLOTYPE.—V. 23182.

DESCRIPTION.—*Fruit:* Elongate, bipartite, syncarpous, dehiscing septicidally into two many-seeded valves, the seeds being immersed in a coarse-celled substance (pulp ?) and closely and symmetrically arranged in two long parallel rows in each of the longitudinal valves into which the fruit breaks (Pl. XXXI, figs. 8–11). An outer fruit wall is evidenced by a film of cellular matter separated from the coarse-celled mass by a film of pyrites. Each seed is sunk in a smoothly finished pocket in the mass (Pl. XXXI, fig. 11); the coarse parenchyma cells measure about 0·05 mm. in diameter. Immediately around each of the pockets external to the pocket-lining, the parenchymatous cells become much smaller, more compacted, and transversely aligned. Down the centre of each valve they are also smaller, and form the outer cylinder of an axis, the core of which is formed of spirally thickened fibres. In this part of the fruit they are oblong and aligned longitudinally, but diverging from them are transversely aligned oblong cells, measuring 0·0125 to 0·025 mm., which appear to form the smooth septa. Similar transverse cells are continued from the outer end of each pocket to the periphery where, as the result of abrasion, they form a sequence of small slightly oblique ridges of harder texture than the surrounding matrix (Pl. XXXI, fig. 8), which becomes worn down between them. The lining of each seed-pocket is formed of minute polygonal cells about 0·0125 mm. in diameter. Length of fruit always imperfect; diameter, 5 mm.

Seed: The seeds are sub-ovate in outline with one nearly straight and one convex margin, and somewhat compressed laterally (Pl. XXXI, figs. 10–14). As they lie in the fruit all the straight margins are turned towards the septum, the convex margins towards the exterior; the narrow ends are directed towards the periphery and lie close to the septum (Pl. XXXI, fig. 11); the ends towards the axis of the fruit are smoothly rounded. The testa is lined by polygonal cells, 0·017 mm. in diameter, which give a smooth shining surface. At the narrow end of the seed (that towards the periphery) is an organ, probably the micropyle. Arising at this end, in every seed that we have been able to separate, is a closely adhering crest of pyrites which lies along the straight margin. When endeavouring to remove this crest, in every case the surface of the seed broke away nearly to the blunt rounded end, which suggests that the crest may have been connected with the raphe. We have found no satisfactory evidence as to the position of the chalaza, but the remains of decayed organic matter, and the direction of the cells on two specimens, suggest that it was placed excentrically on one of the flattened faces near the rounded end. On the other hand, there is some slight evidence that it may be on the straight margin where the crest ends. In either case the seed would be anatropous. Length of seed, 1·4 mm.; greatest diameter, 1 mm.; least diameter, 0·5 mm.

Remarks.—Four broken septicidal valves, with seed-pockets, from Sheppey, and one fragment of a valve, with seeds, found by ourselves at Minster. The alignment of the seeds, the fact that an organ, which must almost certainly have been the micropyle, can be seen at the narrow end, and the shape of the seeds with the crest along the straight margin, suggest that they were anatropous, the hilum being adjacent to the micropyle. There is no evidence of any direct connexion of the seeds with the axis, but there is definite evidence that the sheathing cells of the axis are continuous with, and similar to the sheathing cells of the seed-pockets and that these cells are continued to the periphery. If, then, the seeds are anatropous, as suggested, the micropyle being towards the periphery of the fruit, the placentation must have been parietal, but if the seeds should prove to be orthotropous, then the placentation must have been axile. We have not been able to trace the relationship of this distinctive species.

V. 23182 Holotype, figured Pl. XXXI, figs. 7, 8. Valve of a fruit (imperfect) with seed-pockets. The specimen shows the fine cells lining the seed-pockets and continued to the periphery, where, as the result of differential abrasion, they form slight ridges.

V. 23183 Figured Pl. XXXI, fig. 9. Another similar valve, with seeds in some of the seed-pockets.

V. 23184 Figured Pl. XXXI, figs. 10, 11. A valve (V. 23184, fig. 10) and section across it (V. 23184*a*, fig. 11).

All the above are from the Bowerbank Coll., Sheppey.

V. 23185 Figured Pl. XXXI, figs. 12–14. Three isolated seeds (figs. 12–14), and V. 23185*a* the valve from which they were obtained. *Reid & Chandler Coll.*, Minster, 1929.

V. 23186 A broken valve. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 20

PLATE XXXI, fig. 15.

The much-worn, narrow valve of a large loculicidal fruit, oval in outline but truncate at the base. The valve is broadly triangular in section owing to a median longitudinal angle on the inner face no doubt associated with a septum ; it is formed of coarse parenchyma, the cells appearing to measure as much as 0·15 mm. in diameter, but the substance is so decayed that it is difficult to know whether these really are individual cells. The exterior, also much decayed, is of finer texture.

The shape and dimensions of the valve suggest that the fruit to which it belonged was formed by the union of five or six carpels.

V. 23187 Figured Pl. XXXI, fig. 15. The valve of a large loculicidal fruit, now fractured transversely. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 21

PLATE XXXI, figs. 16–18.

The specimen is an ovoid, one-celled, one-seeded fruit, the seed being abortive. The pericarp is formed of an outer coat of parenchyma, 0·5 mm. thick, preserved in part only (Pl. XXXI, figs. 16, 17). Within is a second coat formed of coarse loose parenchyma which surrounds the locule containing the abortive seed. The seed is pendulous and inverted, attached to the truncate base of the fruit by a long funicle (Pl. XXXI, figs. 17, 18). The testa is formed of parenchyma. We cannot determine the relationship of this specimen. Length of fruit, 7·5 mm.

V. 23188 Figured Pl. XXXI, figs. 16–18. A fruit with an abortive seed. *Reid & Chandler Coll.*, Sheppey, 1928.

Carpolithus sp. 22

PLATE XXXI, fig. 19.

The fruit is globular, one-loculed, dehiscing into two symmetric, slightly hollowed, hemispherical valves, the locule between being lenticular in shape. The carpel wall is smooth externally, and in section consists of fine parenchyma with globular or ovoid secreting cells. The locule-lining is formed of minute parenchymatous cells; its surface is rough. Diameter, 7 mm.

One fruit, which on fracturing parted into two valves, to one of which a locule-cast adhered. The valve and locule-cast both showed the cells of the locule-lining. Each valve was then transversely fractured, showing that there was but a single lenticular locule.

V. 23189 Figured Pl. XXXI, fig. 19. A two-valved unilocular fruit. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 23

PLATE XXXI, figs. 20, 21.

A large sub-ovoid endocarp, distorted by pressure, one-loculed, one-seeded, dehiscing into two valves. No organs have been seen, but three coats are wholly or in part preserved. An outside coat, from 0·5 to 0·7 mm. thick, preserved in small patches, formed of fine, close parenchyma with a general radial alignment of the cells. A middle thick coat, very nodular and rugose externally, from 1 to 1·2 mm. thick, also formed of parenchyma, the cells being more irregularly arranged than in the outer coat and sometimes (result of decay ?) having a granular appearance. The lining layers of this coat are formed of cells about five times as long as they are broad, aligned variously, so that the arrangement of the cells on its inner surface appears confused and sometimes tortuous. The innermost coat (testa ?), about 0·2 mm. thick, has a smooth outer surface, but shows a granular texture, where the outer surface is worn away. Fibres (the raphe ?) are seen associated with this coat, in one patch only. Diameters, $27 \times 22 \times 18$ mm.

The outer and innermost coats retain much of their carbonaceous matter, but the specimen is heavily pyritized. The endocarp, although almost perfect, showed no trace of organs, but a ridge of pyrites (Pl. XXXI, fig. 20) suggests a plane of dehiscence into two equal valves. When attempting to fracture the specimen transversely, it broke into several fragments. One of these (Pl. XXXI, fig. 21) showed an abortive seed. We have been unable to determine the relationship.

V. 23190 Figured Pl. XXXI, figs. 20, 21. A fruit, fractured to show the structure. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 24

PLATE XXXI, fig. 22.

A one-celled, one-seeded endocarp, ovoid but slightly compressed laterally. The carpel wall is formed of two coats, an outer thick coat of parenchyma and an inner thin coat of elongate cells (fibres ? seen only in one small patch). The length is 6·3 mm.; breadth, 4 mm.

The seed approximates to the shape of the locule; it is indented (accidentally ?) along the margin, near one end, and here there may be organs now covered with pyrites. The testa is formed externally of large hexagonal cells (secreting cells ?), 1 mm. in diameter, and is lined by small quadrate or polygonal cells, 0·025 mm. in diameter. Length, 5·5 mm.; breadth, 3·5 mm.

We do not know what the affinity may be.

V. 23191 Figured Pl. XXXI, fig. 22. An endocarp, fractured to show the enclosed seed.
V. 23192 A second specimen (locule-cast or seed-cast), possibly referable to this species.
Both are Reid & Chandler Coll., Minster, 1929.

Carpolithus sp. 25

PLATE XXXI, figs. 23, 24.

The fruit is sub-ovate in outline, roundly pentangular in section, five-loculed, syncarpous, dehiscing septicidally. The surface, as preserved, is rugose; there is a conspicuous circular scar at the broad end. The pericarp is very loose-textured, formed chiefly of parenchyma in which are embedded fibres and a number of longitudinal ducts of circular cross-section; these latter being found especially around the locules. The locules, which are sub-triangular in transverse section, are lined by a coat of transversely aligned fibres. Length, 15·7 mm.; diameter, 13·5 mm.

The surface shows a few narrow longitudinal ridges of pyrites which appear to be due to the infilling of fissures caused by dehiscence. The specimen was fractured, at first longitudinally, then transversely. Owing to the cavernous nature of the pyrites filling the locules, and to the loose texture of the pericarp, the fractures were very irregular and the specimen fell into many pieces, but it was possible to trace the form of the locules.

V. 23193 Figured Pl. XXXI, figs. 23, 24. A five-loculed fruit, fractured to show the structure. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 26

PLATE XXXI, figs. 25–27.

Fruit: Roundly triangular in outline, two sides being shorter than the third (Pl. XXXI, fig. 25), somewhat compressed laterally, thick-walled, one-loculed. At the point where the two shorter sides meet, there was either the style or the attachment, probably the latter; externally the cells are aligned from this point, and internally there is a similar alignment in some of the coats. A thick strand of fibres (funicle ?), suggesting the attachment, enters the thick wall of the locule at this point and passes within its thickness to the opposite pole (Pl. XXXI, fig. 26), where it enters the locule. The carpel wall is formed of loosely compacted cells aligned around the funicle at right-angles to that organ. Externally the surface is formed of close-set, fairly regular, polygonal cells about 0·05 mm. in diameter. Within the thickness of the wall on a shining pyrites surface are the impressions of a middle layer of irregular cells rather longer than broad, sometimes twice as long (about 0·05 × 0·025 mm.), aligned irregularly. Within this coat is another formed of several layers of polygonal cells about 0·025 mm. in diameter, aligned longitudinally. This appears to be the locule-lining.

The seed has not been seen. Length of fruit, 3·75 mm.; greatest breadth, 4·6 mm. Length of locule, 2·75 mm.; breadth, 4 mm.

REMARKS.—The fruit was fractured longitudinally, one lateral face (valve ?) breaking away irregularly along the funicle (Pl. XXXI, fig. 26). The locule-cast (Pl. XXXI, fig. 27) was then fractured in the hope that the seed with its organs might be found, but the cast proved to be pyrites throughout. We cannot suggest the relationship of this fossil.

V. 23194 Figured Pl. XXXI, figs. 25–27. A fruit, fractured to show the seed and locule-cast. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 27

PLATE XXXI, figs. 28, 29.

Locule-cast: Sub-globular, somewhat flattened dorsi-ventrally (Pl. XXXI, fig. 28), one-loculed, two-seeded. Locule-lining smooth (possibly formed of small cells with longitudinal alignment) with numerous slender striae running from base to apex. Carpel wall abraded. Diameter of locule, 5·5 mm.

Seed: Hemispherical (the flat faces of the two seeds are appressed in the fruit). Neither hilum nor raphe can be traced, hence it is uncertain whether the seed is orthotropous or anatropous. The micropyle and chalaza lie at opposite poles. Testa thin and smooth, formed of minute equiaxial cells aligned in longitudinal rows which converge to the micropyle and chalaza. Length of seed, 3·5 mm.; breadth, 2 × 4 mm.

REMARKS.—A much-worn locule-cast, with faint striae on its surface, from which the whole of the carpel wall is missing. The form suggested that it contained two seeds; it was therefore fractured along the plane which apparently divided them, thereby revealing the shrunken and crumpled seeds. The convergence of the lines of cells suggested that the chalaza was probably at the pole opposite to the micropyle. Unfortunately, in the neighbourhood of these organs, the locule-cast and seed become so closely associated that the two surfaces cannot be separated or distinctly traced. Hence the actual organs cannot be seen.

The characters of fruit and seed are insufficiently defined to permit of identification of the specimen.

V. 23195 Figured Pl. XXXI, figs. 28, 29. A two-seeded fruit, fractured along the plane between the two seeds. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 28

PLATE XXXI, figs. 30–32.

A sub-ovoid pyrites cast, rounded on one side (Pl. XXXI, fig. 31) and with two more or less flattened surfaces meeting at an angle on the other (Pl. XXXI, fig. 30). Along this angle, at one end, are adherent remains of a strand of fibres, and fragments of carpel wall. Hence it seems probable that the specimen represents a carpel which was attached at the angle to a fibrous axis. Judging by the size of this ventral angle there were probably four such carpels in the perfect fruit. Along the median line of the rounded dorsal surface there is an inconspicuous longitudinal groove (Pl. XXXI, fig. 31). This may be the impression of a median fibre in the carpel wall if the cast is a locule-cast. On the other hand, the cast may be that of a solitary thin-walled seed with the remains of the carpel and axis still adhering in the hilar region. In this case the groove on the dorsal surface may mark the position of the raphe, or the junction of two collateral cotyledons. The surface of the cast shows impressions of polygonal cells with rather irregularly thickened walls. If it be a seed there is no evidence to show whether it was erect or pendulous. Length, 5·5 mm.; dorsi-ventral diameter, 3 mm.; breadth, 4 mm.

V. 23196 Figured Pl. XXXI, figs. 30–32. A locule-cast, or seed-cast with remains of axis and carpel walls. The specimen is broken and shows nothing but pyrites throughout. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 29

PLATE XXXI, figs. 33, 34.

A sub-ovate, four-sided fruit (?), four-angled at the narrow end, where there is a quadrangular hole. From the four corners of this hole four narrow longitudinal grooves (one partly obliterated) pass between the adjacent margins of four flat faces which correspond in position to the four sides of the terminal hole (Pl. XXXI, fig. 33). At about the middle of the fruit (?) the flat faces and angles merge into the rounded base (Pl. XXXI, fig. 34), although the grooves and longitudinal fibres which are associated with them are continued a little below the middle. The integument is smooth and formed of parenchyma. When sectioned the specimen showed no further structure but merely the thickness of the parenchymatous coat, the interior being filled with crystalline pyrites. Length, 5 mm.; breadth, 5 mm.

V. 23197 Figured Pl. XXXI, figs. 33, 34. A fruit (?), now fractured. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 30

PLATE XXXI, fig. 35.

The specimen consists of two separate fragments, the half of an inner sub-globular cast and an outer shell. The cast, which had been ground down before it came into our hands, shows a median section. The shell was found in a separate jar, but when placed over the cast fitted it exactly. There can be no doubt therefore that the two fragments belong together. The only evidence of structure is in regard to the integuments, for the section shows nothing but an infilling of the cavity by solid pyrites. The shell (carpel ?) is formed throughout of parenchyma, except that on its inner surface are longitudinal bands of fibres; some fibres may have pierced the outer surface, for this is continually interrupted as though by their ingress or egress. The solid pyrites cast (Pl. XXXI, fig. 35) shows on its surface corrugations and small rectangular cells, 0·01 mm. in diameter, both being longitudinally aligned from a small terminal scar (fig. 35). It may be either a locule-cast or seed-cast. Length of specimen without shell, 14 mm.; diameter, 16 mm. The specimen bears some slight general resemblance to Lauraceae, but the evidence available is insufficient for identification.

V. 23198 Figured Pl. XXXI, fig. 35. Half of a locule-cast, with the remains of an outer coat (carpel ?). *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 31

PLATE XXXI, figs. 36, 37.

A transversely ovoid, one-loculed, one-seeded endocarp, bisymmetric about a plane containing the longest and shortest axes. The carpel wall is thick, rough externally (as preserved), formed of coarse parenchyma in which large strands of fibres are embedded towards the periphery. Length, 11 mm.; maximum transverse diameter, 14·5 mm.; least transverse diameter, 12 mm.

The seed is much shrunken but seems originally to have conformed in shape to the locule. The testa is thin, formed of one or two ? layers of rather deep large polygonal cells.

The fruit was first fractured in the plane of symmetry, whereupon the crumpled seed was seen lying within the thick-walled carpel. One half was then fractured transversely, showing definitely that the specimen was one-seeded, but owing to the crumpled, shrunk condition the organs of the seed were not seen.

We cannot determine the relationship of this specimen, but the bisymmetric woody endocarp with a solitary seed recalls the Icacinaceae. The evidence is, however, too obscure to permit of relating it to that family.

V. 23199 Figured Pl. XXXI, figs. 36, 37. An endocarp, fractured to show the seed. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 32

PLATE XXXI, figs. 38, 39.

The specimen is obovate in outline and laterally compressed, slightly emarginate at the apex and with a small conical protuberance in the middle of the emargination. It is covered by a coat of small equal-sized irregularly polygonal cells in which is embedded an elaborate system of branching and anastomosing fibres. Outside this coat was an outer thick coat of which a few fragments only now remain; it is formed of angular woody parenchyma. Length, 9 mm.; breadth, 7 mm.; thickness, 3 mm.

The specimen was much encrusted with pyrites, which was later chipped away, when most of the outer woody coat also came away, leaving the inner coat and fibres exposed. The specimen is probably a seed to which (originally) some of the endocarp remained attached. If so, the coat of polygonal cells with embedded fibres would be the testa ; the apical protuberance would either be the cast of the stylar canal which has remained attached to the seed, or it would be the radicular end of the seed itself. The outer woody coat must be part of the pericarp, most probably the endocarp. The specimen may be related to the Icacinaceae, but the evidence is quite inconclusive.

V. 23200 Figured Pl. XXXI, figs. 38, 39. A seed, with remains of the surrounding endocarp. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 33 [*C. gracilis* (Bowerbank) ?]

Plate XXXI, fig. 40.

An elongate-ovoid, three-lobed specimen seems to represent the internal cast of a three-lobed or three-loculed fruit. The cast is narrowed at both ends, and the lobes are separated by three deep longitudinal grooves which extend from the base to the apex. The surface of the cast shows the impression of elongate fusiform cells, longitudinally aligned over the lobes, obliquely aligned in the grooves. The specimen was fractured transversely, and then showed several sectioned seeds (of small diameter). One seed had a terminal chalaza and a testa with coarse inflated cells. Further attempts to expose a seed more completely were unsuccessful. Length of cast, 10·3 mm. ; diameter, 4·7 mm.

In size, shape, and number of lobes this specimen corresponds with *Carpolithus gracilis* (Bowerbank) (p. 503), but although the facts known about the two agree, the evidence is inadequate to prove identity in the absence of Bowerbank's original specimens.

V. 23201 Figured Pl. XXXI, fig. 40. An internal cast of a three-lobed fruit. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 34

Plate XXXI, figs. 41, 42.

Endocarp woody, globular, one-loculed, one-seeded, very thick-walled, splitting into symmetric halves on germination (Pl. XXXI, fig. 41), the contiguous surfaces of the valves being smooth. Locule ovoid, seed pendulous, placenta lateral, but whether the whole of the lateral ridge seen in Pl. XXXI, fig. 42, represents the funicle, or may in part represent the raphe there is no evidence to show. That is, we do not know whether the hilum was basal, or lateral near the entrance of the funicle. The base of the stylar canal is indicated by a small mucro on the locule-cast (Pl. XXXI, fig. 42) ; it is the cast of the stylar canal. Both the carpel, and the parenchymatous cells (0·03 mm. in diameter) of which it is formed, have preserved their shape undistorted, so that the carpel wall was probably hard and woody. The locule-lining is formed of two layers of cells, the outer layer having a transverse alignment, and the inner layer a longitudinal alignment, the cells converging both to the base and apex. The seed is too shrunken for study ; the testa was evidently formed of small cells. Length of specimen, 10 mm.; diameter, 12 to 13 mm. The locule-cast gives the approximate dimensions of the seed, length, 6 mm.; breadth, 4 mm.

When broken the endocarp split into two valves along the natural plane of dehiscence, exposing the locule-cast. This was subsequently fractured to expose the seed, which, however, proved to be so abortive and shrunken that it gave no further information. We do not know what the relationship of this specimen may be.

V. 23202 Figured Pl. XXXI, figs. 41–42. A two-valved endocarp, now fractured in an attempt to expose the seed. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 35

PLATE XXXII, fig. 1.

The specimen is the external cast of an achene preserved on two counterpart halves of a block of cement stone from Assington, Suffolk. It is ovate in outline and somewhat compressed, produced at the apex into a flat triangular style. The surface is corrugated transversely, the corrugations forming fairly sharp ridges which were either coarsely tubercled or, more probably, spiny. The achene apparently tended to split into two valves along a median plane between the flattened faces. The white matrix which shows in the left-hand impression (Pl. XXXII, fig. 1) is merely due to a break in the carpel which exposes the matrix below. Length (slightly broken), 4 mm.; breadth, 2·2 mm.; thickness, about 1 mm.

We cannot determine the specimen, but the character of the surface is so peculiar that probably it could readily be recognized again and, if found in a better state of preservation, the anatomy could be studied more adequately. If, further, a comparable pericarp were seen among living fruits of similar form, it would then be possible to determine the relationship of the specimen.

V. 23203 Figured Pl. XXXII, fig. 1. Two counterpart fragments showing the impressions of a fruit. *John Brown Coll.*, Assington, Suffolk.

Carpolithus sp. 36

PLATE XXXII, fig. 2.

The specimen is probably an internal cast of a five-partite, one-loculed, many-seeded fruit with parietal placentation. The small seeds show obscurely beneath the worn surface of the locule-cast, and more clearly in an oblique section of the cast. They appear to be arranged in parallel rows, one row on each side of five longitudinal grooves which may mark the courses of five placental ridges. On the more or less flattened surfaces between the grooves are faint median longitudinal ridges (representing shallow channels on the locule itself) from which pairs of oblique lines diverge. These can be seen in the figure. They are probably the impressions of fibres associated with the pericarp. Length of cast, 14 mm.; diameter, 9 mm.

The seeds are small, with a testa, thick in proportion to their size, formed of parenchyma and minutely pitted externally.

The specimen, having begun to break diagonally, was fractured. It then showed the seeds lying close to the periphery, and the mode of placentation.

V. 23204 Figured Pl. XXXII, fig. 2. Cast of a five-partite fruit. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 37

PLATE XXXII, fig. 3.

An obovoid pentagonal specimen, probably represents the internal cast of a five-partite, syncarpous, one-loculed fruit. There are slight remains of the pericarp which show a coat with radial alignment of its cells, and an inner fibrous coat. The centre of the cast shows some organic remains which are quite unrecognizable. No trace of septa has been seen. Length, 16·5 mm. ; breadth, 14·5 mm.

V. 23205 Figured Pl. XXXII, fig. 3. A pentagonal locule-cast. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 38

PLATE XXXII, figs. 4–9.

Carpel unilocular, one-seeded, obovate, symmetrical about two median planes at right angles to one another, somewhat compressed so as to be oval in transverse section. Some specimens have a more or less conspicuous median longitudinal groove on the two broader faces (Pl. XXXII, figs. 4–7), others have not. In all, a median longitudinal band of fibres passes along each face in the position of the groove. The apex shows two adjacent circular scars (Pl. XXXII, fig. 5), the larger merely a surface scar, the smaller a definite opening, through which a bundle of fibres passes to the interior. At the opposite extremity of the best-preserved specimen there is also a passage to the interior. When the fruit is sectioned the vascular bundle entering the apex is seen to continue its course for some little distance. In two specimens (abortive ?) in which the locule was obliterated this was rather more than half the length of the specimen ; but in a third specimen it merely pierces the wall and then disappears. In a well-preserved specimen which was fractured longitudinally the following coats were seen : (1) A thick woody coat, preserved in a few patches only (Pl. XXXII, figs. 8, 9), formed of small equiaxial cells. (2) A spongy coat of coarse but thin-walled cells which forms the main thickness of the carpel (as preserved) (Pl. XXXII, fig. 9). The thickness of this coat is remarkable, measuring in parts one-quarter of the diameter of the specimen. The inner limits of the coat are not very clearly defined, as the locule cavity is occupied by pyrites which also fills the cell cavities and the interstices of the coat just described. Arising at about one-third the length of the specimen from its base, and on the side of the carpel where the inner spongy coat is thickest, is a single seed (Pl. XXXII, fig. 9). It does not fill the locule, but although it is not shrivelled it may be abortive. As preserved, and as seen in section, it appears to be peltate or saucer-shaped with a thickened rim, and is attached by the middle of its convex face.

There are fifteen specimens in all, of which twelve were collected by ourselves at Minster and three belong to the Bowerbank Collection. One of Bowerbank's specimens was labelled "*Iriartea eocenica*" by Ettingshausen. It has no relationship whatever to any palm. The fruits differ considerably, not only in size but in shape. The external character which at a first glance indicates a connexion between them is the peculiar pair of scars always seen at the apex. As the superficial appearance did not furnish any clue as to their nature or as to the morphological significance of the various organs, some specimens were fractured and they then showed the characters described above. Nevertheless, we were not able to determine the species.

V. 23206 Figured Pl. XXXII, figs. 4–7. A fruit (endocarp ?). *Bowerbank Coll.*, Sheppey.
V. 23207 Figured Pl. XXXII, figs. 8, 9. A second specimen, with the woody outer coat in part preserved. Fractured longitudinally to show the seed, and afterwards transversely also. *Bowerbank Coll.*, Sheppey.
V. 23208 A small endocarp, now fractured into three pieces. *Reid & Chandler Coll.*, Minster, 1928.
V. 23209 Eleven specimens (three now fractured). *Reid & Chandler Coll.*, Minster, 1929.
V. 23210 One somewhat abraded specimen. Labelled by Ettingshausen "*Iriartea eocenica.*" *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 39

Plate XXXII, fig. 10.

Seed large, oval in profile, markedly trigonous in section throughout its length but with slightly unequal faces. Testa thin, formed of close, fine parenchyma; tegmen formed of minute, flat, oblong or angular cells. Length, 20 mm.; breadth of the three faces, 9, 10, and 11 mm. respectively.

One specimen only, broken longitudinally before it came into our hands. It appears to be the internal cast of a seed with fragments of testa adhering. At first sight it bears a superficial resemblance to an endocarp of *Canarium*, but there can be no true relationship as there are no traces of valves; moreover, the cell-structure of the inner integument is so highly characteristic of the tegmen of a seed, that the fossil must be regarded as a seed and not as an endocarp. We made comparison with various seeds of the Taxaceae, but although comparable in size, none of them is so sharply triangular at both ends. Moreover, their cell-structure is unlike that of the fossil. We cannot suggest its relationship.

V. 23211 Figured Pl. XXXII, fig. 10. A large trigonous seed, imperfect on one side. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 40

Plate XXXII, fig. 11.

The specimen shows six cylindrical masses of pyrites grouped symmetrically around a central cylinder of pyrites. It may represent a six-lobed syncarpous fruit, the axis of which is decayed, or a group of six large seeds attached to a central placenta now decayed. A thin, rough coat covers the surface. We cannot determine the specimen. Length, 14·5 mm.; diameter, 10 mm.

V. 23212 Figured Pl. XXXII, fig. 11. A six-lobed specimen. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 41

Plate XXXII, figs. 12, 13.

A locule-cast with remains of the pericarp adhering, bisymmetric, obovate in outline (Pl. XXXII, fig. 12) and much compressed. At the broad end, as seen in section, is the remains of loose tissue which probably represents the placenta. Within the cast is a large seed of similar shape (see left-hand side of fig. 12, Pl. XXXII; also fig. 13). It has organs at the two ends; that at the broad end, which probably represents the hilum and micropyle, is depressed and obscured by pyrites; that at the narrow end is small, round, and black, and probably represents the chalaza. The quadrangular cells of the testa (0·03 mm. in diameter) are aligned transversely and encircle these two organs concentrically. The remains of the pericarp are much decayed, but it was evidently formed of parenchyma, the impressions of its cells (0·025 mm. in diameter) remaining on the locule-cast. In form the seed suggests those of *Magnolia*, but there is no evidence of the peculiar thickening and plug associated with the chalaza in that genus, and the integuments are quite unlike those of *Magnolia*. The cells of the fossil more recall the testa cells of many Icacinaceae, but the structure is not otherwise comparable with fruits or seeds of that family. Length of locule-cast, 5·4 mm.; diameter incomplete, half the breadth, approximately 2·7 mm. Length of seed, 4·3 mm.; breadth, 5 mm.

V. 23213 Figured Pl. XXXII, figs. 12, 13. A broken locule-cast containing a seed. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 42

Plate XXXII, figs. 14, 15.

Endocarp almond-shaped. The outer coat (as preserved) formed of large elongate cells, variously aligned, which give the appearance of having been succulent. Embedded within this coat, more especially towards its inner surface, are broad, thick bands of fibres, some longitudinal, some tortuous. Passing inwards this coat is followed by two layers of pyrites; one is smooth and shining but shows no distinguishable cells, the other shows the convex impressions of cells indicating a pitted surface. Length (slightly imperfect), 24 mm.; greatest diameter, 16 mm.; least diameter, 11 mm.

Two specimens. The better preserved (Pl. XXXII, figs. 14, 15) showed part of the endocarp; the other showed only the impressions of its cells on a layer of pyrites. Both showed patches of the two inner coats (impressions only) but not in juxtaposition or in such a manner as to enable us to understand their relationship to one another. The poorer specimen was fractured, but without revealing anything further. We have not been able to determine the affinity.

V. 23214 Figured Pl. XXXII, figs. 14, 15. A worn endocarp.
V. 23215 A worn and distorted locule-cast, now fractured.
Both are from the Bowerbank Coll., Sheppey.

Carpolithus sp. 43

Plate XXXII, figs. 16, 17.

The specimen is ovoid, four-angled, and stipitate. It is embraced by four large adherent appendages (bracts ?) with valvate reduplicate aestivation which meet at the four angles. At the base there seem to be obscure remains (perhaps two whorls) of other small appendages, one row alternating with the large ones. The large appendages were thick, and may have been fleshy ; they are formed of parenchyma and the longitudinally striate surface consists of small square or oblong cells. A transverse section shows that within these appendages lies a confused group of organs having a more or less symmetrical quadrilateral arrangement around a circular core of pyrites (Pl. XXXII, fig. 17). Length, 10 mm. ; greatest breadth, 6 mm.

The specimen suggests an inflorescence with bracts and floral organs embedded in pyrites. The size and four-partite shape and the alignment of the cells suggest a possible alliance with the Epacridaceae, a fruit of which family has been recognized from the deposit and described on p. 464, Pl. XXVI, figs. 18–20.

V. 23216 Figured Pl. XXXII, figs. 16, 17. A four-partite infloresence or fruit with adherent perianth, fractured to show the structure. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 44

Plate XXXII, fig. 18.

A broken, thick-walled woody valve of a two-valved bisymmetric endocarp. The specimen consists of parenchyma with a radial alignment. No trace of style or attachment can be seen, but the form suggests that the attachment, and perhaps the style also, lay at the extremity now broken away. The lenticular locule is lined by elongate, transversely aligned cells, 0·001 mm. in diameter. The cavity is lined by a shell of pyrites, the inner surface of which (seen in Pl. XXXII, fig. 18) bears the impression of two coats of the testa, the outer coat formed of irregular angular cells, 0·017 mm. in diameter, and the inner of larger angular cells, 0·05 mm. in diameter. Length imperfect ; breadth, 18 mm. ; thickness, 10 mm.

The shape of this thick-walled fruit suggests alliance with Menispermaceae, and if the style were adjacent to the attachment (now broken away) this alliance would be possible. At the same time there is no trace of any central condyle such as is almost universal in the family. Consequently the evidence as to this affinity is inconclusive. The convex area in the middle of the locule (seen in the figure) is merely the impression, on the pyrites lining the locule, of an accidental concavity (due to shrinkage ?) on the surface of the seed. The locule-wall behind the pyrites shows an uninterrupted concave surface.

V. 23217 Figured Pl. XXXII, fig. 18. A broken valve of a large two-valved endocarp. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 45

PLATE XXXII, fig. 19.

The specimen is greatly decayed and abraded, and much distorted by compression ; the fibrous pericarp remains only in a few patches between the protruding locule-casts. There are ten of these sub-cylindric casts which appear to have been grouped around a central fibrous axis. The locule-lining is formed of transverse cells or fibres. No seeds were found. The specimen is too decayed and badly characterized to attempt determination.

V. 23218 Figured Pl. XXXII, fig. 19. An abraded fruit with locule-casts exposed. Now in two fragments. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 46

PLATE XXXII, figs. 20, 21.

An ovoid endocarp, bisymmetric and laterally compressed, conspicuously ornamented with a coarse network of large ridges between which are flattened or concave areas such as are seen in the endocarps of some of the Icacinaceae and in *Brucea* (Simarubaceae). The endocarp, as preserved, is thin. The outer layers are formed of coarse parenchyma, and the lining of large, long, somewhat inflated cells variously aligned so as to give a sinuous effect. The solitary seed is of the same form as the nut, the cells of the testa are small, but are so ill-defined that they cannot be measured. There is no evidence regarding the position of the funicle or the organs of the seed. Length, 7·6 mm. ; breadth, 6 mm. ; thickness, 4 mm.

One specimen only is definitely known. We attempted to section it, but only a small part of the carpel wall chipped away showing the structures of the testa and pericarp. Despite the superficial resemblance to Icacinaceae, the structure of the pericarp is unlike that of any fruits we have seen in that family. There is more resemblance to the carpels of *Brucea*. As in the fossil, the external layers of the endocarp of *Brucea* are sometimes formed of granular parenchyma and the locule-lining of elongate inflated cells. But these cells are shorter than the corresponding cells of the fossil, and although variously aligned do not produce the same tortuous appearance. The evidence, therefore, will not warrant reference to either family, and we know of no others which have endocarps similar to the fossil in size and form.

A second specimen, one of two, in a jar labelled by Ettingshausen "*Cyperites* sp." may be related to *Carpolithus* sp. 46, as evidenced by its shape and size and by the character of the cells forming the locule-lining. The contours are, however, smoother, showing little evidence of the ridges and depressions seen in the first-described specimen, but this may be a consequence of individual variation. The cell structure is so similar in the two specimens that we think it possible they belong to a single species. Neither this specimen nor that associated with it in the jar can possibly be related to the Cyperaceae. The cell structure is entirely different from what is found in nuts belonging to that family.

V. 23219 Figured Pl. XXXII, figs. 20, 21. An endocarp. *Bowerbank Coll.*, Sheppey.
V. 23220 An endocarp, perhaps referable to the same species. Labelled by Ettingshausen "*Cyperites* sp." *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 47

PLATE XXXII, figs. 22–24.

The specimen is an endocarp, so abraded as to be virtually a locule-cast, but on one side, protected by a hard cover of adherent pyrites, a small patch of the thick endocarp itself is preserved. The cast is 17·5 mm. long, 12 × 6 mm. broad; it is pointed-ovate in outline (Pl. XXXII, figs. 22, 23), oval in transverse section (cf. Pl. XXXII, fig. 24), with a well-marked longitudinal angle on one broad face (Pl. XXXII, fig. 23) and a more irregular, less well-defined angle on the other (Pl. XXXII, fig. 22). The surface of the cast is boldly sculptured into ridges and hollows, and upon it can be seen the impressions of the transverse cells or fibres which formed the locule-lining. In places, however, the cast is so abraded that the surface exposed is that of the solitary anatropous seed within, the testa being formed of angular cells, 0·05 mm. in diameter. Where the seed is best exposed, close to one of the longitudinal angles described above, is a longitudinal strand of fibres, the raphe, which lies in the thickness of the testa (Pl. XXXII, fig. 23).

We fractured the specimen transversely. The fracture showed the seed-cast covered by the testa lying within the locule-cast, and within, another cast covered by the tegmen which had partially collapsed and become longitudinally folded so that it had shrunk from the testa. We then chipped away the locule-cast and seed-cast and found at one end of the tegmen the smooth circular chalaza into which the raphe could be traced. The cells of the tegmen can be seen only near the chalaza, and then only as impressions; they are elongate, but irregular in shape, with irregularly thickened walls, and are aligned in longitudinal rows which radiate from the chalaza. Elsewhere the surface of the seed-cast is so crumpled that the cells forming the tegmen are obscure.

The form and sculpture of the cast suggest relationship with the Icacinaceae, but the testa cells are unlike those of any Icacinaceae known to us. The longitudinal angles on the broad faces are also unlike the Icacinaceae in which the angles are marginal, but this difference may be merely the result of distortion. The evidence is on the whole insufficient to justify ascription to the Icacinaceae. We do not know any other family to which the specimen can be related.

V. 23221 Figured Pl. XXXII, figs. 22–24. A locule-cast fractured to show a seed within. Labelled by Ettingshausen "*Carpolithes* sp." *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 48

Plate XXXII, figs. 25–27.

A sub-ovoid locule-cast, 9·5 mm. long, 5 mm. in diameter, pointed at either end, bisymmetric about a plane through a pair of median longitudinal ridges, one dorsal, one ventral (Pl. XXXII, figs. 25, 26). In profile (Pl. XXXII, fig. 27) the dorsal surface is somewhat convex, the ventral surface more markedly convex and produced at the middle into a small sharp beak. Between the beak and one extremity lies one of the median ridges described above ; between the beak and the other extremity is a large aperture with smooth incurved edges (Pl. XXXII, fig. 26). The junction of ventral and dorsal surfaces is marked by marginal angles (Pl. XXXII, fig. 27). The surface of the cast shows the impressions of a layer of fibres, aligned transversely over most of the surface but radially around the ventral aperture and prominence. Part of the pericarp is preserved at both ends on the dorsal surface ; it thins where it abuts against the median and lateral ridges in such a manner as to suggest that these mark planes of dehiscence (now filled by pyrites). The finished margin of the ventral hole must indicate that it is the cast of a fibro-vascular bundle which passed into the locule from the ventral wall of the fruit, and after becoming embedded in pyrites, decayed, leaving a cavity in the locule-cast.

The specimen was fractured in an attempt to discover the form and character of the seed. Unfortunately, it broke into fragments, exposing all that remained of the seed—a mass of decayed carbonaceous matter. When these fragments were cleared away from the inside of the locule-cast the impression of the corrugated surface of a seed was seen on its surface. The irregular form indicated that considerable shrinkage had occurred, but the corrugations were too uniform in character and arrangement to be merely the result of shrinkage. We were unable to determine the specimen.

V. 23222 Figured Pl. XXXII, figs. 25–27. A locule-cast with fragmentary remains of pericarp on the dorsal surface. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 49

Plate XXXII, figs. 28–31.

Eight specimens are the locule-casts of some species of fruit. They are ovoid (or obovoid ?) in outline, and roundly pentangular in transverse section. The surface is, for the most part, formed of a layer of transverse sinuous fibres, but lying over these in a few places are the remains of a coat of parenchyma, the cells being, possibly, digitate. One specimen shows, within the coat of transverse fibres, strands of longitudinal fibres which arise from a sub-circular area at the broader end (Pl. XXXII, fig. 30). These are embedded in a tissue composed of large cells variously aligned. How far these fibres are continued over the whole surface, there is no evidence to show. At the narrow end of the same specimen is a circular hole which probably is the cast of the funicle as it enters the locule. Consequently it probably marks the position of the placenta. The fruit was probably one-loculed and formed from five carpels. We fractured one specimen, but it proved to be merely a cast without any seeds.

V. 23223 Figured Pl. XXXII, figs. 28, 29. A locule-cast with remains of the pericarp.
V. 23224 Figured Pl. XXXII, fig. 30. A locule-cast, showing longitudinal fibres within the coat of transverse fibres.
V. 23225 Figured Pl. XXXII, fig. 31. A markedly pentangular locule-cast.
V. 23226 An imperfect locule-cast.
All the above are from the Bowerbank Coll., Sheppey.
V. 23227 Four casts. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 50

PLATE XXXII, figs. 32, 33.

Specimen truncate-ovoid, somewhat laterally compressed, bisymmetric, having an elliptical scar at the truncate end. Outer coat fibrous, the fibres converging from the scar to the narrow end; inner coat smooth, formed of polygonal cells. Length in plane of symmetry, 8·3 mm.; diameter in same plane, 6·3 mm.; thickness at right angles to plane of symmetry, 5 mm.

We cannot determine the specimen.

V. 23228 Figured Pl. XXXII, figs. 32, 33. An abraded seed. *Bowerbank Coll.*, Sheppey.

Carpolithus sp. 51

PLATE XXXII, figs. 34, 35.

A globular fruit or endocarp, truncate at the base with shallow longitudinal ribs (or wrinkles ?). The wall was originally thick, formed of parenchyma, the cells being arranged radially in section. It is now largely abraded except at the truncate base, where it is thickened considerably over a concavity (Pl. XXXII, fig. 35) filled with pyrites, which has accumulated around a median projection. Length, 6 mm.; diameter, $6 \times 5{\cdot}5$ mm.

V. 23229 Figured Pl. XXXII, figs. 34, 35. A fruit or endocarp. *Reid & Chandler Coll.*, Minster, 1929.

Carpolithus sp. 52

PLATE XXXII, fig. 36.

The specimen is the larger half (in longitudinal section) of the internal cast of a one-loculed fruit with remains of the pericarp still adhering to it. It is elongate-ovoid with several (probably eight) sharp longitudinal ribs; but because of its imperfect condition and the presence of folds and crumples it is impossible to determine the original number. The locule-lining (seen on the surface of the cast) shows elongate cells with a general longitudinal alignment, but towards the ends of the cast, with an oblique alignment, the cells here diverging from some (but not all) of the ridges.

The pericarp where preserved is formed of similar long cells, and in places there are obscure indications of polygonal cells. The specimen has been ground down, naturally or artificially, in a longitudinal direction so that but little more than half is preserved. As seen in section the pyrites which fills it is permeated throughout by delicate filiform strands, sometimes with a shining black surface, suggesting that they were hairs or single cells. Length, 18 mm.; diameter (rather distorted), about 7 mm.

We fractured the specimen transversely in order to ascertain whether or not any seeds were preserved. Superficially it bears a great resemblance to the fruit of *Eleagnus*, and there is a further resemblance between the two in the long filiform hairs within the locule. Nevertheless there are distinctions which must exclude it from that genus: it is larger than the fruit of any species of *Eleagnus* we have seen; the cells of the pericarp are dissimilar; and in *Eleagnus* the cells are not longitudinally or obliquely aligned.

V. 23230 Figured Pl. XXXII, fig. 36. Broken internal cast of a fruit. *Bowerbank Coll.*, Sheppey.

UNIDENTIFIABLE FRUITS OR SEEDS

Among the specimens of fruits or seeds in the Bowerbank Collection which were too imperfect and too poorly preserved to be worth cataloguing, were some which were labelled as follows by Ettingshausen: *Cyperites* sp., *Smilax* sp. n. 2, *Iriartea eocenica*, *Elaeis eocenica*, *Faboidea*, *Leguminosites*, *Apeibopsis variabilis*, *Sapindus Sheppyensis*, and *Carpolithes* sp. 33.

WOOD, STEMS, AND TWIGS

We have already commented (p. 23) on the abundance of wood at Sheppey and Herne Bay, and it is indeed frequent at most localities where the London Clay is exposed. Countless small pyritized twigs and stem fragments are strewn on the shore at Sheppey, but the structure is not usually well preserved. Larger specimens, up to several feet in length, may be wholly or only partly pyritized, or more rarely calcified, and are often teredo-bored. According to Johnson (1876, p. 159), who was the first to apply the method of etching smoothed surfaces of pyritized wood with nitric acid, so that the woody structure was left standing in relief, the walls of these tissues "appear to have been silicified," but this needs confirmation, and is certainly not always the case.

Apart from the conifer *Cupressinoxylon Holdenae* mentioned above (p. 102), Bowerbank's account of a wood which he named *Piper* sp. (1844, p. 16, pl. ii, figs. 1–5) is the only one so far published. The details given, including the occurrence of tyloses, are, however, inadequate for identification, and Thiselton Dyer pointed out in 1872 (p. 243) that other genera might well be in question. In the same paper Dyer dealt with further material from the Eocene of Kent, but did not state clearly the provenance of his figured (but unnamed) specimens; it seems likely that they were from the Thanetian of Reculvers, and not the London Clay.

The structure is sometimes fairly well preserved, but it has not been found possible to include descriptions of the dicotyledonous woods in this volume, and they are reserved for separate treatment.

Among the specimens of rolled and abraded wood in the Bowerbank collection were some simulating fruits or cones, which were labelled with various names by Ettingshausen. Most have now decayed, and none is worth cataloguing.

RECEPTACLES ?

Plate XXXII, figs. 37, 38.

An ovoid body with a series of cup-shaped hollows on its surface, which are very irregular in size, form, and spacing (Pl. XXXII, fig. 37). In section the specimen shows a central axis of close woody fibres enclosing a column of pith. Around the axis (Pl. XXXII, fig. 38) the specimen is formed of close radially aligned woody fibres with pitted walls. These are crossed by broad medullary rays. Near the surface the fibres diverge to form the walls of the small cup-shaped hollows, and fill also the spaces between them, so that at the surface they twine in and out along the margins of the hollows, and often coil upon themselves as serpentine folds of fine fibres. The specimen is 14·5 mm. long (imperfect), and 13 mm. in diameter. It may be a receptacle of some kind, but against such a possibility is the fact that we could detect no definite order in the arrangement of the hollows.

The specimen cannot belong to any cone-bearing tree such as the Coniferae or the Betulaceae. We have compared it with *Liquidambar*, but it is quite unlike the fruiting-heads of that genus, which have not the compact woody structure of the fossil. We do not know its relationship. There are several similar but less well-preserved specimens.

V. 23231 Figured Pl. XXXII, figs. 37, 38. A specimen in two fragments.
V. 23232 Several woody specimens with cavities over the surface, now filled with pyrites. They may be receptacles.

All are from the Bowerbank Coll., Sheppey.

BURRS, BORED WOOD, GALLS, ETC.

A large number of woody specimens, usually hollowed to form one or more chambers of varying form, the chambers now being filled with pyrites. Among them must be included Bowerbank's supposed genus *Xulinosprionites*, with which we deal separately below. We have made many attempts to discover the nature of these objects and their mode of origin. They do not show the structure of fruits or seeds. Thinking that they might be galls, or growths formed by the activity of some tunneling animal, we consulted various authorities. Mr. H. N. Ridley, F.R.S., thought that they might be " burrs " (abortive buds) such as are found on many tree trunks. Photographs were sent to Dr. Houard, Director of the Botanical Institute and Gardens of Strasbourg. He reported on them as follows : " J'ai étudié les cécidies actuelles de toutes les régions tropicales du Globe,—Amérique, Afrique, Asie, Océanie—mais aucune d'elles ne rapelle les dessins que vous m'avez envoyés. Il faut plutôt chercher parmi les galles des chênes d'Amérique et même d'Europe, pour trouver des cavités larvaires globuleuses, limitées par une paroi ligneuse, mince et dure, qui rapellent les deux photos [Pl. XXXIII, figs. 13, 20]. Autour de ces cavités, le tissu spongieux fossile rapelle aussi celui des galles."

The photographs were then kindly sent by Mr. W. N. Edwards to Mr. A. W. Bartlett and Dr. Heslop Harrison. Mr. Bartlett replied that they agreed with Dr. Houard's suggestion that the specimens illustrated in Pl. XXXIII, figs. 13, 20, might represent cynipid galls. Dr. Heslop Harrison thought that the specimen in Pl. XXXIII, fig. 26, might represent a water-worn willow-gall, "if willows existed during the London Clay period." He also thought that the specimens in Pl. XXXIII, figs. 6–8, 21, 27, and 28 probably showed the work of animals and "that they might represent tunnels made in wood by larvae of Lepidoptera and Coleoptera, which afterwards became filled up by a deposit of some kind." But Mr. Bartlett found some difficulty in accepting this explanation, "in that the cavities occur at about the middle of the nodules." On receipt of Mr. Bartlett's letter Mr. Edwards showed the photographs to Mr. K. G. Blair, who doubted whether the specimens in Pl. XXXIII, figs. 6–8, 21, could be due to beetles because beetle galleries in wood ought to show an enlarged pupation chamber somewhere.

As it seemed impossible, therefore, to obtain any certain information as regards these bodies, we have sorted them into groups according to their structure. They belong to several well-defined types and have been illustrated and catalogued accordingly. Unless otherwise stated, the specimens belong to the Bowerbank Collection from Sheppey.

It is interesting to notice that Crow (1810) in his manuscript catalogue says of the Sheppey fossils: "Some that were thought to be fruits have proved to be Excrescences of Insects after the manner of Oak-galls, etc."

(1) *Bodies showing definite fine woody structure with well-developed medullary rays.*

(*a*) Those having narrow cylindrical cavities opening to the exterior at one end only (Plate XXXIII, figs. 1, 2, 5–8).

V. 23233 Figured Pl. XXXIII, figs. 1, 2. A specimen showing the exterior and the aperture at one extremity.

V. 23234 Figured Pl. XXXIII, figs. 5, 6. A specimen showing the smooth exterior. Fractured longitudinally to show the cavity now filled with pyrites.

V. 23235 Figured Pl. XXXIII, fig. 7. A globular specimen, fractured longitudinally. It shows the cavity very clearly.

V. 23236 Figured Pl. XXXIII, fig. 8. Another smaller example.

V. 23237 250 woody nodules with narrow cylindrical cavities and woody structure.

V. 23238 Six decayed or decaying specimens with similar structure, labelled "*Asterocaryum Europaeum*" by Ettingshausen.

V. 23239 Two specimens. *Reid & Chandler Coll.*, Minster, 1929.

(*b*) Those having one or more globular or sub-globular cavities, usually with a small aperture at each extremity (Plate XXXIII, figs. 9–13).

1840. *Xulinosprionites* Bowerbank, p. 142.

Under the generic name *Xulinosprionites* Bowerbank placed certain specimens which he separated into two species and appears to have regarded as belonging to the family Leguminosae, since it is with members of this family that he compares them, and his generic description is "*Legumes* valveless, woody, two-seeded."

There are many of these specimens. They are often more or less constricted in the middle, and usually longitudinally striate when the outer layers are worn away, the striae converging to the two extremities. Very rarely a pitted peripheral coat is preserved, the pits being oblong and arranged in longitudinal rows (Pl. XXXIII, fig. 11). The pitted external layer may be the epidermis, but the rectangular pits may be due to an underlying network of fibrous strands with short transverse branches. The walls of these specimens are thick and woody, the wood fibres being aligned longitudinally and crossed by medullary rays. The peripheral layers tend to separate from the inner ones, and appear less compacted though otherwise of similar structure. The constricted specimens (*Xulinosprionites* Bowerbank) are two-chambered, but other specimens show no constriction and are one-chambered (Pl. XXXIII, fig. 9). The chambers are globose and lined by much decayed carbonaceous matter; they narrow at the extremities to form small apertures, and are now filled by pyrites. One specimen is fractured transversely through the partition between the two chambers. The partition shows the structure of an ordinary twig or branch. There is no evidence in any specimen of a marginal carpellary rib such as occurs in the Leguminosae.

Among the two-chambered specimens it is possible to recognize some comparable with "*Xulinosprionites zingiberiformis* Bowerbank" (Pl. XXXIII, figs. 10, 11) and others which resemble "*Xulinosprionites latus* Bowerbank" (Pl. XXXIII, figs. 12, 13).

V. 23240 Figured Pl. XXXIII, fig. 9. An unconstricted specimen, fractured longitudinally, with one cavity filled with pyrites, and an aperture at each end.

V. 23241 Figured Pl. XXXIII, fig. 10. A two-chambered specimen of the type named by Bowerbank "*Xulinosprionites zingiberiformis*." The lower lobe is fractured obliquely to show one of the cavities.

V. 23242 Figured Pl. XXXIII, fig. 11. A stout two-chambered specimen of the same general type.

V. 23243 Figured Pl. XXXIII, figs. 12, 13. A two-chambered specimen of the type of "*Xulinosprionites latus* Bowerbank." Fractured longitudinally to show the cavity.

V. 23244 Ten two-chambered specimens (*Xulinosprionites*).

V. 23245 100 one-chambered specimens.

V. 23246 Twelve fragmentary specimens of the same type. Labelled by Ettingshausen "*Elaeis eocenica* Ett."

V. 23247 A one-chambered specimen showing clearly the longitudinal rows of oblong pits on the external surface. *Reid & Chandler Coll.*, Warden, 1928.

(*c*) Those with elongate cavities, and ribbed external surfaces, the ribs having the appearance of coarse fibro-vascular bundles (Pl. XXXIII, figs. 14–18).

V. 23248 Figured Pl. XXXIII, fig. 16. Ribbed specimen simulating a fruit.

V. 23249 Figured Pl. XXXIII, figs. 14, 15. Another specimen, fractured to show the pyrites filling the cavity.

V. 23250 Figured Pl. XXXIII, figs. 17, 18. Another smaller specimen.

(*d*) Woody specimens of various types which have not been referred to groups (*a*), (*b*), or (*c*).

V. 23251 Twelve woody nodules with curved or hook-shaped cavities now filled with pyrites.
V. 23252 Seventy-five woody nodules, bored ? showing various forms of cavity or burrow.
V. 23253 Thirty woody nodules with various types of cavity.
V. 23254 Two nodules with cavities or bore holes. Fractured longitudinally. Labelled by Ettingshausen "*Elaeis eocenica.*"
V. 23255 A nodule, fractured longitudinally to show the bore or cavity. *Reid & Chandler Coll.*, Warden, 1928.
V. 23256 A nodule with a narrow cavity. *D. J. Jenkins Coll.*, Herne Bay.

(2) *Bodies formed of coarse parenchymatous cells more or less radially arranged, without typical ligneous structure.*

(*a*) Those with large spindle-shaped cavities opening to the exterior at one end only (Pl. XXXIII, figs. 3, 4). A specimen of this type appears to have been figured by W. Jones (1781, pl. v, fig. *a*).

V. 23257 Figured Pl. XXXIII, figs. 3, 4. A specimen fractured to show the cavity filled with pyrites.
V. 23258 Twenty specimens in various states of abrasion. Some are so worn that nothing remains but the hard pyritized cast of the spindle-shaped cavity.
V. 23259 Another specimen, much decayed, in pieces. Labelled by Ettingshausen "*Asterocaryum Europaeum.*"
V. 23260 Another specimen, now in pieces and much decayed, labelled "*Liquidambar eocenicum*" by Ettingshausen.

(*b*) Those with sub-globular cavities with one or more exits, now filled with pyrites (Pl. XXXIII, figs. 19–21).

V. 23261 Figured Pl. XXXIII, figs. 19, 20. A specimen fractured longitudinally to expose the cavity.
V. 23262 Figured Pl. XXXIII, fig. 21. Another specimen with finer parenchyma. Half only is preserved.
V. 23263 A specimen fractured to expose the cavity, labelled by Ettingshausen "*Elaeis eocenica* Ett."
V. 23264 Twenty similar specimens.

(*c*) Certain other types with parenchyma (Pl. XXXIII, figs. 22–25).

V. 23265 Figured Pl. XXXIII, fig. 22. A small nodule, fractured longitudinally.
In. 31396 Figured Pl. XXXIII, figs. 23–25. A woody specimen with a large central cavity and coarse radially aligned parenchyma. On fracturing this specimen the remains of an insect pupa were found lying within the pyrites which occupied the cavity. According to Dr. F. W. Edwards, the pupa is indeterminable ; it is either lepidopterous or dipterous, and is possibly a tipulid. The specimen was labelled "*Asterocaryum Europaeum*" by Ettingshausen.

(3) *Spindle-shaped or conical bodies with no central cavity.*

The specimens are formed of coarse angular parenchyma arranged more or less radially around a fibrous core (Pl. XXXIII, fig. 28). Many of the fibres in the core are finely sinuous. Several small scars, like the "eyes" of a potato, can be seen on the external surface (Pl. XXXIII, fig. 26). If the specimens are galls these may mark the points of emergence of insects.

V. 23266 Figured Pl. XXXIII, fig. 26. A specimen figured to show the exterior.
V. 23267 Figured Pl. XXXIII, figs. 27, 28. A small specimen fractured longitudinally to show the fibrous core.
V. 23268 Ten specimens. Labelled by Ettingshausen "*Amomum* sp."
V. 23269 Ten specimens.

CONCRETIONS

PLATE XXXIII, figs. 29–37.

Numerous bodies of a concretionary nature occur upon the foreshore at Sheppey among the vegetable debris. Their inorganic character is usually recognizable at a glance, but in a few instances they so closely simulate fruits or seeds in appearance that a careful examination is necessary before their true nature can be determined. On fracture, these bodies are seen to be composed of radiating crystalline pyrites or sometimes of fine-grained pyrites. A few of the more deceptive specimens are figured and catalogued.

V. 23270 Figured Pl. XXXIII, figs. 29–31. Concretion simulating a bean in appearance. *W. Griffiths Coll.*, Sheppey.

V. 23271 Figured Pl. XXXIII, fig. 32. A concretion simulating a fruit in its cupule, such as *Quercus*, or some of the Lauraceae.

V. 23272 Figured Pl. XXXIII, figs. 33–35. Concretion described and figured by Bowerbank as *Cupressinites tesselatus* (1840, p. 63, pl. x, figs. 30, 31). The specimen, which is now broken, is formed of a mass of crystalline pyrites.

V. 23273 Figured Pl. XXXIII, figs. 36, 37. Concretion simulating a palm seed, labelled by Ettingshausen "*Asterocaryum Europaeum*." A circular scar on one side simulates an enormous embryo and on the other a triradiate scar simulates a specimen derived from three fused seeds. On fracture the specimen showed radiating concretionary structure.

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An asterisk (*) indicates a Figure.

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EXPLANATION OF PLATES

Unless otherwise stated, all figured specimens are from Sheppey.

All except the specimen figured on Plate XXX, figures 22, 23, *are in the Geological Department, British Museum (Natural History).*

PLATE I

Explanation of Plate I

FIG.

Araucarites sp., p. 92. V. 22000.

1.—Portion of twig. × 2.

2.—Portion of lower surface of a leaf, to show alignment of stomata. × 6.

Cupressinites curtus Bowerbank, p. 96. V. 22004.

3.—A cone with apex tilted forward. Three scales are perfect; the fourth, to the right and behind, is broken. × 1·7.

4.—The base of the same cone, showing the four scales. × 1·7.

Cephalotaxus Bowerbanki n. sp., p. 99.

5.—A seed. The upper part shows the apical ridge; at the break below, the testa is seen in section. × 1·87. V. 22006.

6.—Seed, showing how the apical ridge dies out below. × 1·87. V. 22007.

Taxaceae, Genus ?, p. 101.

7.—Internal cast of seed. × 1·25. V. 22008.

8.—The same cast, apex, showing the three apical ridges. × 1·3.

Oncosperma anglica n. sp., p. 103. V. 22009.

9.—Internal cast of seed, ventral face, showing hilum (*h*), raphe (*r*), and chalaza (*ch*). × 2·8.

10.—The same, to show the embryo (*e*). × 2·8.

Caryotispermum cantiense n. gen. & sp., p. 104. V. 22010.

11.—Seed, internal cast, side view, showing cavity formerly occupied by embryo. × 2·45.

12.—The same seed, base, showing triangular hilar area (*h*). × 2·45.

Sabal grandisperma n. sp., p. 105. V. 22011.

13.—Internal cast of seed, ventral face, showing large basal cavity filled by remains of raphe and chalaza; the hole is the entrance of the raphe. × 2·2.

14.—The same seed, dorsal face, showing the embryo-scar. × 2·2.

15.—Section through the same seed, showing the embryo cavity (*e*) in section on the top left (now filled with pyrites), and below, the large ventral cavity with infilling pierced by the canal (*r*) which carried the vascular bundle of the raphe. × 3·85.

Sabal sp. (*grandisperma ?*), p. 107. V. 22013.

16.—Base of a leaf, upper surface, showing ligule and rachis. × 2.

17.—The same, lower surface, showing rachis. × 2.

Serenoa eocenica n. sp., p. 108. V. 22017.

18.—Seed, internal cast, with remains of testa adhering; ventral face showing the large ventral depression filled by remains of raphe and chalaza. × 2.

19.—The same, dorsal face, with embryo-scar (*e*) at the base of an accidental median infold, due to crushing. × 2.

Serenoa sp. ?, p. 109. V. 22020.

20.—Internal cast of seed, ventral face, showing the large elongate ventral depression. × 2·5.

Livistona ? minima n. sp., p. 109. V. 22021.

21.—Seed, internal cast, dorsal surface, showing the small oval scar of the embryo (*e*) (white in the middle of the broken area). × 2·33.

FIG.

22.—The same, ventral face, showing the broad shallow basal channel and the deep ventral depression formerly occupied by the raphe and chalaza. × 2·1.

Palmospermum Jenkinsi n. gen. & sp., p. 110. V. 22022.

23.—Seed, internal cast, ventral face, showing large ventral depression filled by raphe and chalaza. × 2·5. Herne Bay.

24.—The same seed, showing the embryo adjoining the hilum. × 2·5.

Palmospermum excavatum n. sp., p. 111.

25.—Internal cast of seed with some of the testa, showing the hollow which carried the raphe. The tongue of pyrites projecting over the ventral depression is probably the internal cast of the raphe canal leading to the internal chalaza, which lies beneath the testa at the top of the figure. × 2·1. V. 22023.

26.—The same, with testa removed to show internal chalaza (*ch*) with its fibres. × 2·1.

27.—A larger seed, ventral face, with much of the testa preserved within the ventral depression. × 2·33. V. 22024.

Palmospermum parvum n. sp., p. 113. V. 22029.

28.—Seed, internal cast, ventral face, showing depression occupied by the raphe. The chalaza (*ch*) can just be seen in the dark shadow at the apex. × 2·83. Herne Bay.

29.—The same seed looking on to the large internal chalaza. × 2·83.

Palmospermum minimum n. sp., p. 114. V. 22030.

30.—Seed, internal cast, ventral face, showing large depression filled by raphe and chalaza. × 3.

31.—The same seed, dorsal face, showing embryo-scar (*e*). × 3.

Palmospermum pusillum n. sp., p. 115.

32.—A circular seed, internal cast, ventral face, with central depression associated with raphe and chalaza. The projecting hilar scar is at the base of the figure. × 2·8. V. 22032.

33.—An oval seed, a similar view. × 2·8. V. 22033.

34.—Seed figured in 32, showing lateral embryo (?). The ventral depression is seen in profile to the left, and the hilum at the base. × 2·8.

Palmospermum sp. 6, p. 116. V. 22036.

35.—Seed, internal cast looking rather obliquely on to the ventral hollow. The top left side of the seed has been distorted and crushed. × 2·8. Herne Bay.

36.—The same seed looking on to the embryo-scar. × 2·8.

Palmospermum sp. 7, p. 116. V. 22037.

37.—Seed, internal cast, ventral face. × 2·8.

38.—The same fractured longitudinally to show small deep ventral depression filled by raphe and chalaza. × 2·8.

Palmospermum ? sp. 7 ?, p. 117.

39.—A seed, side. × 2·3. V. 22040.

40.—The same, ventral, showing the chalazal (?) hollow. × 2·3.

41.—Seed, side, with chalazal (?) plug in place. × 2·3. V. 22041.

42.—The same, ventral, with the plug partly removed. × 2·3.

43.—The same, dorsal. × 2.

LONDON CLAY FLORA

Photo M.E.J.C.

CONIFERAE, PALMAE

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PLATE II

Explanation of Plate II

FIG. *Nipa Burtini* (Brongniart), p. 118.

1.—A narrow, but otherwise full-sized fruit, with poorly developed seed (*s*); showing the rarely preserved base. Above, in surface view, is the fibrous sarcocarp; below, the internal cast of of the seed, surrounded by sarcocarp and endocarp in section. × 1. V. 22042.

2.—A small fruit, somewhat compressed. The pericarp is worn away below, showing the internal cast of the seed. Over the upper right side of the figure is the fibrous sarcocarp, and on the left, between sarcocarp and seed-cast, the transverse fibres of the endocarp (*end*) are exposed. × 1·66. V. 22043.

3.—A young or abortive fruit with one flat face. The asymmetric style (*st*), common in young fruits, is on the right. × 0·9. V. 22044.

4.—Internal cast of a seed. Below is the groove corresponding to an infold of the endocarp. × 1. V. 22045.

5.—Base of a fully developed fruit with abraded carpel wall. The cast of the large locule and seed lies within the remains of the carpel (seen in section); at the centre of the cast is the circular scar marking the basal aperture through which the embryo germinated. × 1. V. 22046.

6.—A portion of the seed-cast seen in fig. 4 magnified to show corrugations on the surface of the seed similar to those in *N. fruticans* (figure turned through a right-angle). × 7.

Petrophiloides Richardsonii (Bowerbank), p. 133.

7.—A perfect but worn strobil with stalk. × 1·1. V. 22090.

8.—Portion of a strobil to show the triangular bracts protruding from the mass of pyrites in which they have become embedded. The free imbricate distal ends of the bracts are worn away. × 2·66. V. 22091.

9.—A perfect strobil, more abraded than V. 22091, so that the locule-casts, which reproduce the form of the seeds, project beyond the worn triangular bases of the bracts. To the left of the row of holes, from which locule-casts and sometimes bracts have fallen, are the unlobed apexes of casts; to the right, where the casts themselves are more worn, are the lobes. Each bract and fruit is enclosed by a narrow wall of infiltrated pyrites; the confluence of these walls forms quadrilateral areas, clearly seen near the base of the strobil, where they project beyond the worn bracts. × 3. V. 22093.

10.—A broken and worn strobil. The bracts have almost completely perished, leaving the pyritized casts of the interspaces (in which fruits are buried) projecting. × 1·33. V. 22092.

FIG.

11.—A strobil from which the fruits have fallen and the bracts completely perished, leaving hollow casts in pyrites, the surfaces of which bear impressions of bracts and fruits. × 1·16. V. 22094.

12.—Part of a longitudinal section through a strobil, showing the way in which bracts and fruits arise from the central fibrous axis (left). The carbonaceous remains are dark grey, the lighter grey being pyrites. Remains of bracts, perianth, and carpel wall are all clearly distinguishable. × 6·5. V. 22095.

13.—Part of a transverse section through a strobil. The left-hand fruit is sectioned tangentially so that the locule-cast is exposed in one small patch (white, in centre). It is surrounded by the pericarp, seen in section, from which arises the perianth, also in section (thin undulating line to the right). The middle fruit is tangentially sectioned; it shows two lobes, and the perianth. The lower fruit (median longitudinal section) shows the entire apex of the endocarp, and the two lobes below. × 6·5. V. 22096.

14.—Part of a tangential longitudinal section of a strobil, showing four fruits in transverse section. The top right-hand fruit shows at its base (separated from it by pyrites), the wide triangular-lunate scale. Within this follow in succession the delicate persistent perianth (thin grey line), and the endocarp (thicker and lobed). × 6·5. V. 22097.

15.—A section through the same fruits nearer their bases. The separation of the basal lobes is complete in all, but only in the top and bottom fruits has the section passed through the basi-ventral hollow in which the placenta lies. × 6·5.

16.—Part of a tangential longitudinal section. The middle fruit (cut obliquely) shows two secondary lobes, the left-hand primary lobe being divided, and each lobe being surrounded by the endocarp wall. × 6·5. V. 22097.

17.—Locule-cast, similar in shape to the seed, showing the two lateral lobes. × 6·1. V. 22098.

18.—Locule-cast, ventral side, showing basi-ventral hollow and four lobes. × 6. V. 22099.

19.—Base of a locule-cast showing free ends of lobes with placenta lying between them. × 6. V. 22100.

20.—Longitudinal fracture through the only fruit definitely known to come from Sheppey (Minster). Note the short broad strobil, and externally keeled fruits. × 2·8. V. 22101.

All the specimens of *Petrophiloides Richardsonii*, except V. 22101 (fig. 20), are from Swale Cliff, Herne Bay.

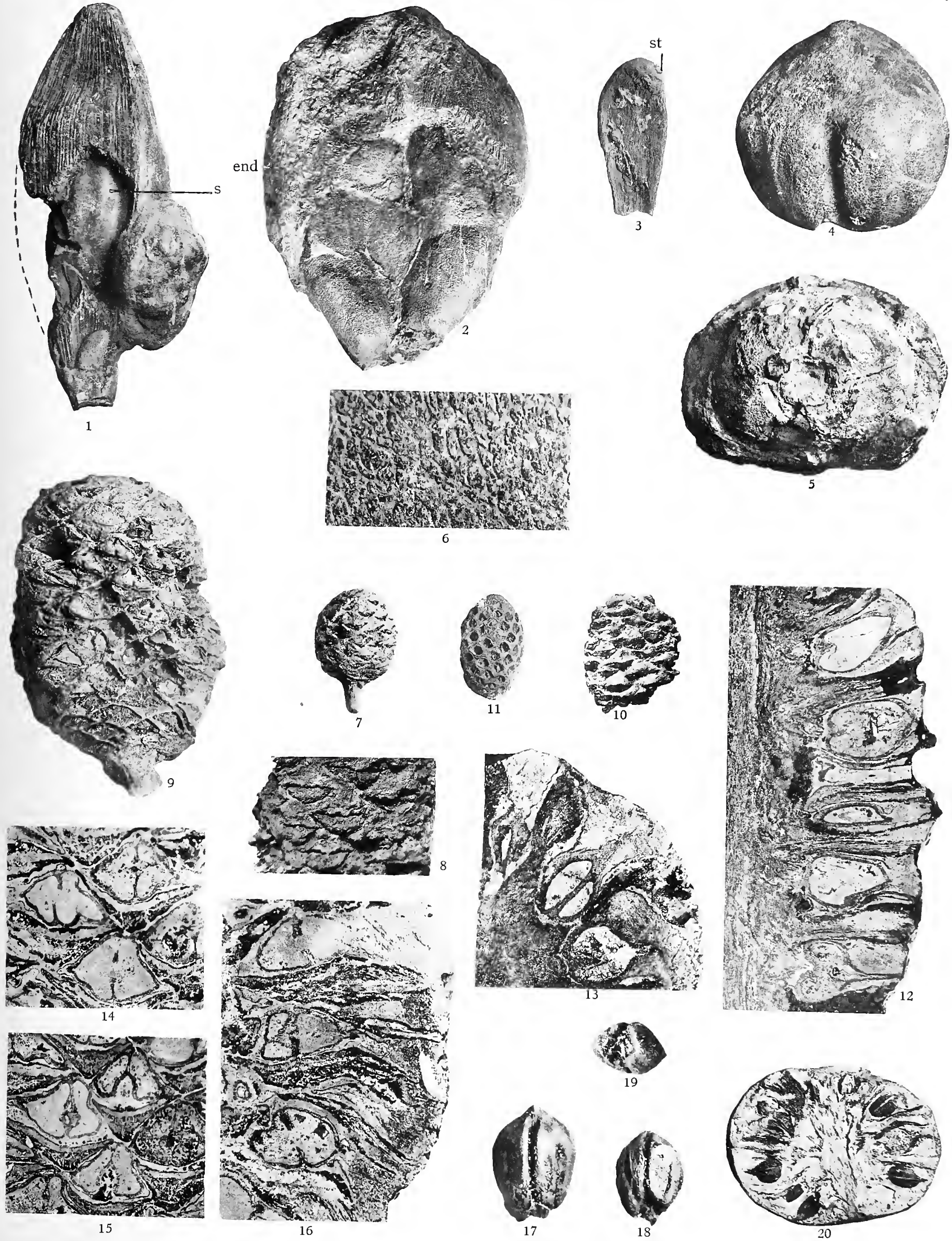

Photo M.E.J.C.

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NIPA, PETROPHILOIDES

PLATE III

Explanation of Plate III

FIG. *Juglandicarya Lubbocki* n. gen. & sp., p. 140. V. 22118.

1.—Half a nut which has split along the suture. Within, the locule-cast simulates the form of the seed and shows one of the lobed cotyledons in surface view. The primary lobes, seen in profile, lie on the right and the left of the receptacle. The surface (matrix) of both lobes has broken off near the base, exposing the true seed-cast within. × 3·14.

2.—The base of the same nut with the two halves in place. The curved plane through the two lateral sutures is the plane of fracture shown in fig. 1. The primary lobes lie right and left of a vertical plane; they are subdivided at the base into the four secondary lobes. × 3.

3.—The locule-cast shown in fig. 1, detached from the shell and seen from the same point of view. The pointed apex corresponds with the radicle, and the two primary lobes below are those of one of the lobed cotyledons. × 3.

4.—The same cast, viewed in a direction at right angles to that of fig. 3, showing the secondary lobes, each equivalent to half a cotyledon. On the left, where the locule-cast is worn, are traces of the nervation of the testa. Above is the pointed radicle. × 3.

Juglandicarya cantia n. sp., p. 142.

5, 6.—Two halves of a nut fractured approximately along the plane of dehiscence. Fig. 5 shows the locule-cast (equivalent in form to the seed) *in situ*; fig. 6 shows the locule itself. The pointed radicle is at the top of fig. 5, and one of the lobed cotyledons is seen in surface view; the primary lobes in this species are not divided, but are slightly emarginate (cf. fig. 7). × 2. V. 22121.

7.—A locule-cast lying in the remains of the carpel, seen at right angles to the plane of dehiscence of the nut, with one of the primary lobes (containing the halves of two cotyledons) in surface view; the lobe is entire except for a slight basal emargination. × 3. V. 22122.

Juglandicarya depressa n. sp., p. 143.

8.—A perfect nut, viewed from above. Note the radiating fibres. × 3. V. 22123.

9.—The same, viewed from the side. × 3.

10.—Nut viewed from the abraded apex; within is the locule-cast (simulating the seed). The flattened, triangular micropylar end is seen as a light transverse line slightly thickened in the middle; at its extremities, right and left, are the two primary lobes. The plane of dehiscence lies horizontally across the figure. × 1·7. V. 22124.

11.—The base of a nut, abraded so as to show the locule-cast (simulating seed) within, aligned as in fig. 10. The plane of dehiscence lies horizontally and shows as a faint white transverse line (due to the infiltration of pyrites). The primary lobes lie right and left of the vertical septum. × 1·7. V. 22125.

12.—A much abraded nut, beginning to split in the plane of dehiscence, as shown by the light transverse band of infiltrated pyrites. × 1·7. V. 22126.

13.—Locule-cast freed from the nut. The plane of dehiscence of the nut lies in the plane of the paper. The micropylar end is directed upwards, and below, one of the cotyledons is seen in surface view, its two lobes lying right and left. Each lobe of the cotyledon forms half of one of the primary lobes of the seed, here seen in profile. × 3·2. V. 22127.

Urticicarpum scutellatum n. gen. & sp., p. 146.

14.—Surface view of one of the flat faces of the endocarp. × 6·6. V. 22133.

Erythropalum europaeum n. sp., p. 147.

15.—Locule-cast, side view. × 3. V. 22134.

16.—Base of same specimen, with seed-cast exposed on the left. × 3.

17.—Another locule-cast with some of the endocarp preserved, apex. The three ridges are formed of pyrites which filled the cracks between the dehiscing valves. × 3. V. 22135.

FIG. *Erythropalum ? striatum* n. sp., p. 149.

18.—A locule-cast with some of the endocarp adhering, side view. The remains of the stalk are incrusted with pyrites. × 2·83. V. 22142.

19.—Another locule-cast with some of the endocarp adhering, apex. The three ridges are formed of pyrites which filled the cracks between the valves. × 2·8. V. 22140.

20.—Another locule-cast, apex, showing the close network of fibres. × 2·83. V. 22141.

Olax depressa n. sp., p. 151.

21.—Locule-cast, side view. × 2·8. V. 22147.

22.—The same specimen, apex. × 2·8.

Protobarclaya eocenica n. gen. & sp., p. 152. V. 22151.

23.—Locule-cast, dorsal view. × 2·2.

24.—Another locule-cast with part of the endocarp adhering, ventral view. × 2·2.

25.—Portion of a fractured locule-cast containing spinescent seeds; most are in transverse section, but the one at the bottom is lying vertically; the section shows the internal cast of the seed and the conical embryotega in place, with its circular base; on the right of this seed is one of the apical spines directed upwards. × 9·5.

26.—Internal cast of a seed showing the circular scar of the embryotega. × 9·5.

27.—A seed, with remains of testa. The small circular scars in vertical rows are spine bases. × 9·5.

28.—Internal cast of seed, side view. The embryotega is at the top. × 9·5.

Trochodendron ? pauciseminum n. sp., p. 155. V. 22152.

29.—Locule-cast to show the shape, side view. × 8.

30.—The same specimen, dorsal view. × 6·6.

31.—Exterior of part of the same specimen after fracture, showing the quadrangular cells which form the inner coat of the testa, and the large coarse fibres lining the locule. × 6·6.

32, 33.—The two portions of the locule-cast after fracture, showing two of the long seeds (*s*). × 8.

Bowerbankella tiliacoroidea n. gen. & sp., p. 158.

34.—An endocarp, exterior of one of the lateral faces showing style (*st*) and attachment (*a*). × 1·8. V. 22154.

35.—An endocarp, base, with median marginal groove (*mg*), marking the plane of dehiscence. × 1·8. V. 22155.

36.—The endocarp seen in fig. 34, showing the marginal groove (*mg*) which marks the plane of dehiscence.

37.—Inner surface of a valve from the margin of which a wedge-shaped fragment has been removed along a natural plane of weakness which corresponds externally with the horse-shoe shaped groove seen in fig. 34, and internally with the inner limit of the curved row of nodules; the locule-lining penetrates this plane of weakness. × 3·2. V. 22156.

38.—Inner surface of a valve from which the locule-cast has been removed; it shows the style (*st*) and attachment (*a*). Note the radially directed fibres which line the locule. × 4·85. V. 22153.

39.—Inner surface of the counterpart valve with the locule-cast lying *in situ*. On both limbs the matrix forming the cast has been chipped away, exposing the seed-cast (best seen at (*s*) on right limb). Within the club-shaped central body lies the funicle, with the placenta at its union with the locule-cast. The hilum (not visible) is marginal on the inner curve of the right limb. × 9. V. 22153.

40.—The locule-cast removed from the same endocarp to show its form. × 5. V. 22153.

41.—A portion of the seed-cast exposed where the locule-cast is chipped away, to show the cells. × 13. V. 22153.

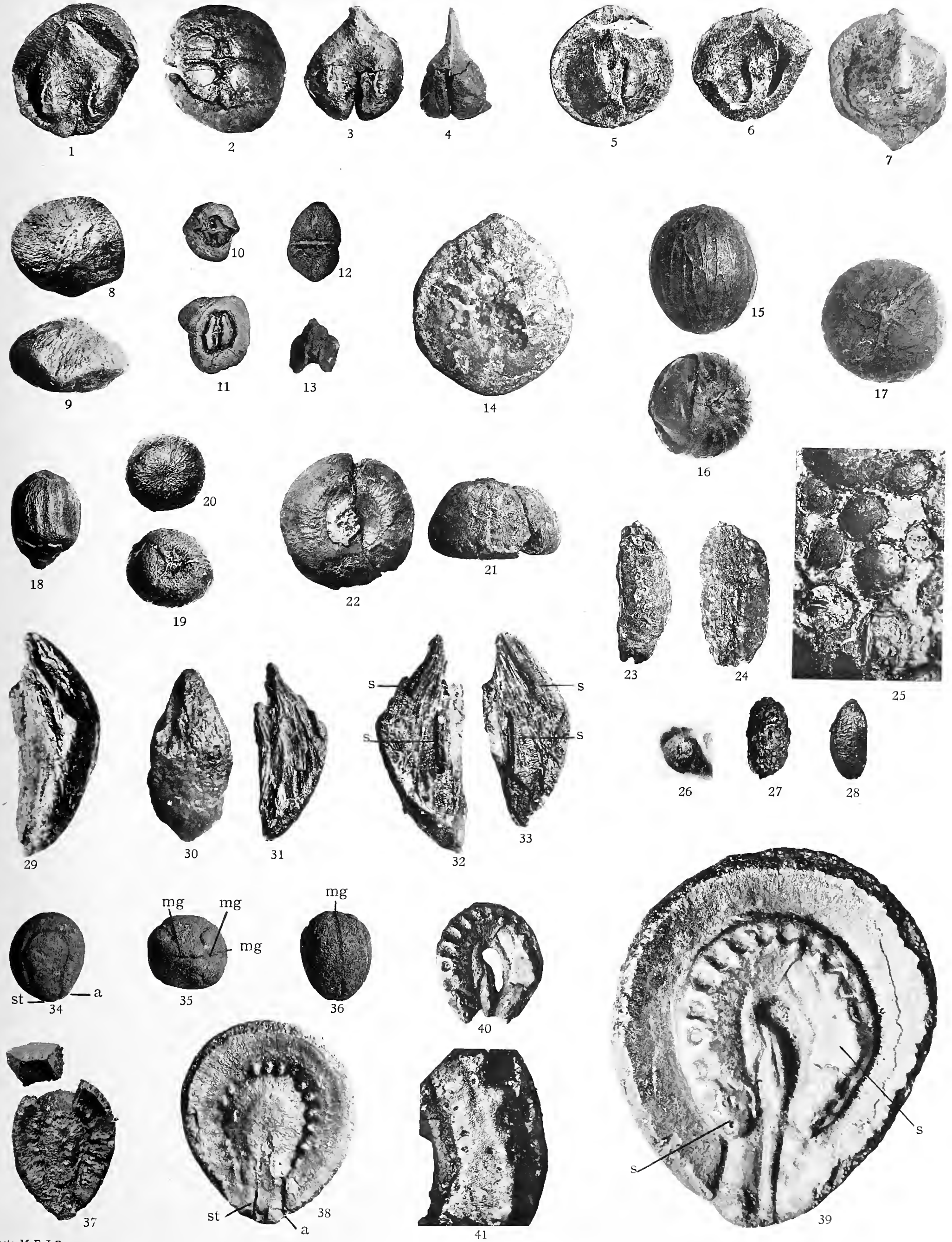

Photo M.E.J.C.

JUGLANDACEAE to MENISPERMACEAE

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PLATE IV

Explanation of Plate IV

FIG. *Tinomiscoidea scaphiformis* n. gen. & sp., p. 162.

1.—Locule-cast with part of the endocarp adhering, ventral face. The sub-apical placenta (*p*) is a raised scar facing the camera. × 2·6. V. 22158.

2.—The same specimen, dorsal face. × 1·53.

3.—End view of the same to show the transverse outline. × 1·3.

4.—Another locule-cast, ventri-lateral, to show the ventral hollow and faceted margin. The placenta is at (*p*). × 1·75. V. 22159.

Microtinomiscium foveolatum n. gen. & sp., p. 164.

5.—Locule-cast, ventral. The sub-apical placenta is at (*p*). × 6·6. V. 22162.

6.—The same specimen, dorsal. × 6·6.

Tinospora excavata n. sp., p. 165.

7.—Locule-cast, ventral. The endocarp is seen in section within the depression, which is otherwise filled with pyrites. × 6. V. 22163.

8.—Transverse section across a locule-cast. The middle is occupied by the large pyrites cast of the ventral hollow. Across its surface is a deep groove (vertical in figure) which corresponds to a ridge on the concave ventral face of the endocarp. × 6. V. 22165.

9.—Longitudinal section through a locule-cast, showing the ventral hollow. × 6. V. 22164.

10.—The internal cast of a seed, ventral, with remains of endocarp in ventral hollow (cf. fig. 7). × 6. V. 22166.

Tinospora rugosa n. sp., p. 167. V. 22178.

11.—Locule-cast covered by a film of much worn endocarp, ventral view. × 6·2. Herne Bay.

2.—The same specimen, lateral view. × 6·2.

Eohypserpa Parsonsi n. gen. & sp., p. 168.

3.—Endocarp, somewhat worn, showing curved form and transverse ribbing. × 2·77. V. 22179.

14.—A worn endocarp with part of locule-cast exposed. × 2·77. V. 22186.

15.—Locule-cast, partly chipped from both limbs, to show seed-cast lying within. × 3·1. V. 22182.

FIG.

16.—A larger locule-cast, preservation typical. × 3·1. V. 22180.

17.—Basal view of a locule-cast. The style and attachment abut upon the groove separating the two limbs; the median line passing from the slight beak (style) marks the plane of dehiscence. × 3. V. 22181.

18.—Locule-cast in transverse section, showing form of seed and the two lateral depressions. × 2·8. V. 22184.

19.—Locule-cast, partly removed to show a pyrites cast of one of the lateral depressions. The slight projection at the base marks the position of the gap between the two limbs of the endocarp; the attachment (broken away) was at (*a*). × 6·3. V. 22183.

20.—A pyrites cast of the other lateral depression in the same specimen, showing the flat inner surface. A portion of the locule-cast still adheres on the right below. × 6·3.

21.—Shrunken seed removed from the locule-cast in which it was embedded. The micropyle is at the extremity of the left-hand limb. × 2·8. V. 22185.

Magnolia longissima (Bowerbank), p. 173. V. 22190.

22.—Seed (broken since Bowerbank figured it), side view. The hilum is at the base, and the chalaza marginal in the hollow at the top. × 5.

23.—The same seed looking on to the large oval chalazal scar. × 5.

24.—A fragment of the testa in section, to show the columnar arrangement of its cells. × 13.

Magnolia lobata (Bowerbank), p. 174. V. 22191.

25.—Internal cast of seed; the raphe lies in the vertical hollow. × 5.

26.—The opposite side of the same; the chalaza is marginal in the hollow at the top. × 5.

27.—The same, looking on to the chalaza. × 5.

Magnolia subquadrangularis (Bowerbank), p. 175. V. 22198.

28.—A seed, side. The broken edges show the thickness of the testa. The raphe lay on this side. × 4·85.

29.—The same, reverse. The longitudinal ridge is accidental and does not mark the raphe. × 4·85.

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MENISPERMACEAE, MAGNOLIACEAE

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PLATE V

Explanation of Plate V

FIG.

Magnolia crassa n. sp., p. 176. V. 22199.

1.—Seed with testa mostly abraded, lateral view. × 4·87.

2.—The same, opposite side, bearing the raphe. × 4·87.

Magnolia subtriangularis n. sp., p. 177.

3.—A perfect seed. × 2·8. V. 22202.

4.—Internal cast (broken) of a seed showing the chalazal scar at the top. × 4. V. 22201.

5.—The same, internal scar of the chalaza. × 13.

Magnolia angusta n. sp., p. 177. V. 22203.

6.—Seed with remains of testa, raphe side. The chalazal plug at the top of the figure is breaking away. × 5.

7.—The same, reverse side. × 5.

8.—The same, showing the external chalazal scar. × 5.

Magnolia sp. (*Magnolia angusta ?*), p. 179. V. 22212.

9.—The chalazal end of a broken seed with testa (black) almost worn away. × 6·5. Harefield.

10.—The same, to show the chalazal scar. × 6·6.

Magnolia subcircularis n. sp., p. 179. V. 22213.

11.—Seed with much of the testa remaining, raphe side. × 4·85.

12.—The same, opposite side. × 4·85.

Magnolia sp., p. 181. V. 22216.

13.—Seed with large tumidity at the chalazal end. × 2·8.

Anonaspermum commune n. sp., p. 184.

14.—Seed, with ruminations showing through the much-worn testa, side view. Note the lateral depression, also (on the right) the groove carrying the raphe. × 2·1. V. 22217.

15.—Internal cast of distorted seed with testa abraded. It shows the ruminations and the raphe arising from the hilum (*h*). × 2·1. V. 22218.

16.—Seed, apex, showing the marginal raphe. × 2. V. 22219.

17.—Seed in transverse section showing the 4-partite arrangement of the ruminations. The white cross is formed of infiltrated pyrites. × 3·1. The specimen has now decayed.

Anonaspermum rotundatum n. sp., p. 186.

18.—A seed with much of the testa remaining. *h*=hilum. × 2. V. 22223.

19.—Internal cast of seed with testa mostly abraded, base, showing hilum (*h*), raphe (*r*), and chalaza below. × 2. V. 22225.

20.—Transverse section showing the 4-partite arrangement of the ruminations. × 3·1. V. 22224.

Anonaspermum rugosum n. sp., p. 186.

21.—Internal cast of seed with worn testa. × 3·16. V. 22229.

22.—The opposite side of the same. × 3·12.

23.—Another seed with testa more completely worn away. × 3·16. V. 22230.

FIG.

24.—Transverse section showing the 4-partite arrangement of the ruminations. × 3·16. V. 22231.

Anonaspermum pulchrum n. sp., p. 187.

25.—Seed, slightly broken, with much of the testa preserved. × 3·16. V. 22233.

26.—Internal cast of another seed showing ruminations, raphe (to the left), and hilum (at the top). × 3·16. V. 22234.

27.—The same, transverse section, showing 4-partite arrangement of the ruminations. × 3.

Anonaspermum minimum n. sp., p. 188. V. 22236.

28.—Internal cast of seed; the testa almost completely abraded. × 2·8.

Anonaspermum punctatum n. sp., p. 189.

29.—Internal cast of seed, side view; the testa is completely abraded. × 3·12. V. 22240.

30.—Internal cast of another seed, base, with hilum at (*h*), raphe above, and strap-shaped chalaza below. × 2·8. V. 22239.

Anonaspermum ovale n. sp., p. 190.

31.—Internal cast of seed showing branching and anastomosing ruminations. × 3·1. V. 22244.

32.—Internal cast of seed (broken at hilum) with some testa adhering. × 2·8. V. 22243.

33.—Seed in transverse section showing bipartite arrangement of the ruminations. × 3. V. 22245.

Anonaspermum complanatum n. sp., p. 191.

34.—Internal cast of seed, with testa preserved over the middle. × 2·85. V. 22249.

35.—Internal cast to show ruminations; hilum at top of figure. × 2·85. V. 22248.

Anonaspermum corrugatum n. sp., p. 191.

36.—Internal cast of seed. × 2·8. V. 22251.

Anonaspermum anoniforme n. sp., p. 192.

37.—Internal cast of seed. × 3. V. 22255.

Anonaspermum subcompressum n. sp., p. 193.

38.—Internal cast of seed. × 2·8. V. 22257.

Anonaspermum obscurum n. sp., p. 193.

39.—Seed with much of the testa preserved. × 2·77. V. 22258.

Anonaspermum cerebellatum n. sp., p. 193. V. 22259.

40.—Fruit much worn. × 2·36.

41.—The same, with part of the pericarp removed, showing two seeds, one above the other. Note the pitting of the seeds, the cord-like raphe (*r*), and the hilum (*h*). × 3.

42.—The same, at right-angles to the last figure. The pits tend to elongate around the circumference of the seeds. × 3.

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MAGNOLIA, ANONASPERMUM

PLATE VI

Explanation of Plate VI

FIG. *Endiandra crassa* n. sp., p. 198.

1.—A large fruit from which the exocarp has been worn away over the middle, thus exposing the endocarp (*e*) and, within it, the seed (*s*). × 1·3. V. 22261.

2.—Shrivelled seed out of the same fruit. The shining rounded area below is the chalaza. × 1·3.

3.—Fibres in the endocarp of the same. × 2·77.

4.—Base of an endocarp with fragments of the exocarp attached. Note the beak-like prominence, overhanging the reniform depressed area pierced by three foramina (filled with projecting masses of pyrites). × 0·9. V. 22260.

5.—Part of one of the inner layers of the mesocarp (or outer layer of the endocarp ?) magnified to show the stellate clusters of cells. × 12. V. 22262.

Cinnamomum globulare n. sp., p. 200.

6.—Berry with epicarp, broken on the right, thus exposing the endocarp. Note the large flat scar of attachment at the base. × 1·5. V. 22267.

7.—Berry with mesocarp preserved, also much of the epicarp (especially at the base). Note the nodular surface (? result of fossilization) and large basal scar. × 2. V. 22268.

8.—Base of another specimen. × 2. V. 22269.

9.—Seed with testa partly removed to show large circular basal chalaza (*ch*, dark grey and smooth) across which can be traced a faint diagonal darker groove, marking the division of the cotyledons. × 2·75. V. 22272.

10.—A seed with testa partly removed. The raphe is marked by the band of vertical striations (impressions of fibres). To the left and right of it are the large secreting cells of the testa. At the base, part of the smooth chalazal area is exposed by removal of the testa. The continuation of the raphe into the groove between the cotyledons is shown in profile at the base of the chalaza. × 6·4. V. 22271.

11.—A section to show the columnar structure of the endocarp. × 6·4. V. 22270.

Cinnamomum grande n. sp., p. 202.

12.—A perfect berry, crushed somewhat from base to apex. × 1·5. V. 22286. Herne Bay.

13.—A berry, with part of the pericarp removed over the middle to expose the seed. On the upper part of the seed are large secreting cells; below is the smooth shining chalaza with the groove (*g*) between the cotyledons. × 2·5. V. 22284.

14.—A seed-cast with remains of the pericarp on the left. This and the testa are almost completely worn away over the rest of the specimen. At the base is the dark, almost hemispherical scar of the chalaza. × 1·75. V. 22285.

Litsea pyriformis n. sp., p. 204. V. 22291.

15.—Fruit in cupule. The uppermost circular area is the projecting locule-cast (*lc*) simulating the seed, the pericarp being here worn away. The figure is deceptive in that there is no discontinuity of surface on either side of the lower transverse line, which is merely a crack across the cupule. × 1·6.

16.—Approximately the same point of view as fig. 15, but the cupule has been fractured longitudinally and removed below the crack. The locule-cast is covered by remains of the pericarp, and the cupule is in section. × 1·6.

17.—The same fruit, apex. The small patch in the centre is an adhering portion of the endocarp. Between the locule-cast and the margin of the cupule is the columnar wall of the thin endocarp in section. × 1·6.

FIG. *Beilschmiedia oviformis* n. sp., p. 205.

18.—Endocarp, exterior, showing the differentially decayed stellate groups of cells giving rise to irregular pits. × 2·85. V. 22295.

19.—Portion of the same, interior. The conical cavity at the apex formerly contained the radicle. × 2·85.

20.—Seed from the same, showing plano-convex cotyledons, and a portion of the locule-cast remaining around the conical radicle. × 2·3.

21.—The same, looking on to the radicle. × 2·3.

22.—Another seed, showing cotyledons and radicle; at (*ch*) is the sinuous margin of the chalaza. × 2. V. 22296.

Beilschmiedia pyriformis n. sp., p. 207.

23.—A pyriform fruit. The carpel is broken and much abraded on the right. × 1·27. V. 22300.

24.—The opposite side of the same. The dark patches in the pericarp on the right near the apex are stellate groups of cells. Within is the seed, one cotyledon, with secreting cells on its surface, being turned to the camera; to the right is the sinuous margin of the chalaza (*ch*); at the apex is the conical radicle (*p*). × 1·66.

25.—Longitudinal section through an ovoid fruit showing the thickness of the pericarp, a fragment of the thick testa (*t*), and the cast of the conical radicle. × 1·2. V. 22301.

Beilschmiedia Bowerbanki n. sp., p. 209.

26.—Fruit, exterior. × 1·27. V. 22303.

27.—The same in section, showing the stellate groups of cells in the exocarp, and the seed (not sectioned) separated from the locule by an infilling of pyrites (white). The chalaza lies to the right, and the conical radicle above; note the corresponding conical apex of the locule. × 1·66.

28.—The seed removed from the same, with the chalaza facing the observer. Note the pointed radicle, the two cotyledons, and the sinuous margin of the chalaza. × 2·6.

Beilschmiedia eocenica n. sp., p. 209. V. 22304.

29.—A fruit from which the carpel has been partly removed to show the seed (below). Note the two cotyledons. × 1·25.

30.—The same, viewed from the opposite side after more of the carpel has been removed. Note the highly sinuous margin of the chalaza (*ch*). × 1·25.

31.—The same, looking on to the radicle (*r*); the sinuosities of the chalaza are seen at the bottom of the figure. × 1·6.

Beilschmiedia gigantea n. sp., p. 211. V. 22308.

32.—Fruit, pericarp preserved in the upper part. The middle is covered by the thin pyritized cast of the locule on which are impressions of large stellate clusters of cells. Where this cast is chipped away at the base the seed is seen with its two cotyledons. × 1·36.

Beilschmiedia ? (or Endiandra ?) crassicuta n. sp., p. 212. V. 22311.

33.—A fruit, somewhat worn at the apex, so that a small portion of the seed and testa appear. The two spherical objects above the seed are merely knobs of pyrites filling hollows in the carpel wall. × 1·1.

34.—The same in longitudinal section showing the cast of the seed (fractured below, entire at the conical radicle) lying within the thick pericarp. × 1·4.

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LAURACEAE

PLATE VII

Explanation of Plate VII

FIG. *Beilschmiedia ?* (or *Endiandra ?*) *fibrosa* n. sp., p. 213.

1.—Berry, exterior. × 2·1. V. 22315.

2.—The same, apex, after partial dissection to show the network of fibres. × 2·1.

Protoravensara sheppeyensis n. gen. & sp., p. 214.

3.—Locule-cast with remains of the endocarp between the ridges. In places the seed is exposed. × 2. V. 22316.

4.—The same, base, with large rayed external chalaza. On the left, near the bottom of the figure, are the edges of the worn endocarp in the grooves. × 2.

5.—Another specimen distorted somewhat obliquely and abraded so as to show the furrowed locule-cast. In the furrows remains of the columnar endocarp are preserved. × 1·75. V. 22317.

Crowella globosa (Bowerbank), p. 216.

6.—Fruit, side, showing the cupule; above, the broken apex of the fruit itself. × 1·63. V. 22321.

7.—Apex of the same fruit showing the three large perianth segments, also the broken locule-cast surrounded by the columnar endocarp in section. × 2·5.

8.—The base of the same fruit. × 1·63.

9.—Side of a young fruit showing the cupule; small segments alternate with the large ones. × 1·63. V. 22320.

10.—A fruit, fractured longitudinally. In the middle is the seed covered by the secreting cells of the testa, surrounded by a layer of pyrites; then follow, in succession, columnar endocarp, thin mesocarp and epicarp (both obscure in the figure but clear in the specimen), and the enveloping segments of the cupule. × 1·66. V. 22322.

11.—The same, with the seed removed, more highly magnified. The columnar endocarp shows best on the right. At the base of the locule a smooth constricted area (*a*) is the scar where fruit and cupule were fused. × 2·75.

Laurocalyx globularis n. gen. & sp., p. 219. V. 22326.

12.—Base of cupule, exterior. × 1·66.

13.—Two fragments of the cupule with pericarp adhering, interior, after removal of the seed-cast. The coats of the pericarp are seen in section. × 1·66.

14.—Seed-cast from the same specimen. Note the circular chalaza (*ch*). × 1·7.

15.—The same seed looking on to the chalaza, which occupies most of the figure. × 1·7.

Laurocalyx fibrotorulosus n. sp. p. 220. V. 22328.

16.—Locule-cast with remains of cupule and pericarp still attached, the latter preserved only beneath the cupule; at (*f*) is the impression of the foramen for the funicle. × 1·3.

17.—The same, opposite side. Note the constriction corresponding to the limit of fusion of the fruit and cupule. × 1·3.

Laurocalyx dubius n. sp., p. 222. V. 22329.

18.—Fruit lying in the broken cupule. × 1·3.

19.—The same with more of the cupule removed to show the carpellary coats. × 1·3.

Laurocalyx Bowerbanki n. sp., p. 223. V. 22330.

20.—Locule-cast lying within the broken cupule; much of the endocarp still adheres to the cast. × 1·5.

21.—Cupule (after removal of the locule-cast), interior, showing the circular scar of attachment of the fruit. × 1·5.

22.—Locule-cast removed from the cupule; part of the endocarp is seen on the right; note the constriction delimiting the scar of attachment of fruit and cupule. × 1·5.

23.—The same, base, to show the large area of attachment, over part of which the locule-cast is chipped away and the seed-cast is seen. × 1·5.

FIG.

24.—The same sectioned longitudinally to show the seed-cast lying within the locule-cast. × 1·3.

Laurocalyx magnus n. sp., p. 224. V. 22332.

25.—Berry in cupule, side, exterior. × 1·2. The specimen is incomplete on the right.

26.—The same with most of the broken cupule removed showing the locule-cast. The endocarp and remains of the decayed exocarp (in section) are not distinguishable in the figure. The thick adherent fragment on the right is the cupule in section. × 1·1.

Laurocarpum sheppeyense n. gen. & sp., p. 225.

27.—Locule-cast, with remains of endocarp, showing the large depression associated with the placenta. × 2·77. V. 22333.

28.—Internal cast of a seed to show the hemispherical chalaza (smooth, dark, and shining, at bottom of figure). × 2·5. V. 22334.

Laurocarpum paradoxum n. sp., p. 226.

29.—Endocarp, side. × 1·66. V. 22338.

30.—The same, apex, showing (in the figure obscurely) the aperture (*f*) for the funicle. × 1·7.

31.—Another endocarp, base. × 1·66. V. 22339.

32.—Seed with remains of the endocarp around the aperture for the funicle. × 2·77. V. 22340.

33.—Seed with remains of the endocarp adhering at the top around the placenta and hilum. × 2. V. 22341.

34.—Internal cast of a seed to show the large shining hemispherical chalaza and the groove between the cotyledons. × 2. V. 22342.

Laurocarpum ovoideum n. sp., p. 228.

35.—A berry, exterior. × 1·4. V. 22354.

36.—The same with part of the pericarp removed, exposing the seed within, partly covered on the left by remains of the endocarp, a small portion of which is seen on the right (obscure in the figure) in section. The upper part of the seed is largely covered by the secreting cells of the testa, and below is the smooth shining chalaza. × 1·5.

37.—The seed removed from the same specimen, with remains of the endocarp adhering around the hilum (top of figure). Note the conspicuous raphe (*r*) and large chalaza (*ch*). × 1·66.

38.—A fruit, showing external ribbing and large basal scar of attachment. × 1·4. V. 22355.

Laurocarpum proteum n. sp., p. 230.

39.—Fruit with part of pericarp removed to show locule-cast below, and, above, seed-cast. The apparent horizontal crack is the free margin of a mass of pyrites corresponding to a fold in the seed. × 1·25. V. 22358.

40.—The base of the same to show the large scar of attachment. × 1·25.

41.—A seed to show the curious depression near the hilum (top of figure). × 1·4. V. 22359.

42.—The same, side. The hilum is at the top of the figure, the raphe along the ridge to the right. × 1·3.

43.—The same, fractured longitudinally to show the thick testa. The raphe is to the left near the base, passing obliquely through the testa and entering the seed-cavity at the circular shining chalaza (dark in figure). × 1·5.

Laurocarpum minimum n. sp., p. 231.

44.—Abraded locule-cast with remains of the endocarp adhering above; elsewhere the specimen shows the secreting cells of the testa. × 2·8. V. 22368.

45.—A seed with some of the testa removed to show the large chalaza (at bottom of figure). × 2·8. V. 22369.

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LAURACEAE

PLATE VIII

Explanation of Plate VIII

FIG.

Laurocarpum minutissimum n. sp., p. 232.

1.—A berry, exterior, side. × 6·5. V. 22372.

2.—Base of the same; part of the pericarp has been removed to expose the seed, and part of the testa to show the chalaza (middle circular area). × 6·5.

3.—The same, side view, showing the seed enveloped by remains of the pericarp. Note the large secreting cells of the testa. × 6·5.

Laurocarpum pyrocarpum n. sp., p. 233.

4.—An abraded fruit. × 2. V. 22375.

Laurocarpum crassum n. sp. p. 234. V. 22377.

5.—Locule-cast showing the placenta with mouth-like scar, around which are remains of the endocarp. × 1.

6.—The same, side view with the placenta at the top. × 1.

Laurocarpum sp. 9, p. 235. V. 22379.

7.—Fruit, apex, from which the pericarp is abraded, thus exposing the locule-cast. × 1·4.

Laurocarpum sp. 10, p. 235. V. 22380.

8.—Fruit with about half of the thick mesocarp preserved (note radial arrangement of its cells). Within it lies the internal cast of the seed, the testa and endocarp being abraded. On the right, a break in the surface of the cast, and the alignment of the neighbouring cells, suggest the displacement of one cotyledon over the other. × 1·1.

Laurocarpum sp. 11, p. 236. V. 22381.

9.—Seed-cast covered by the testa above, showing the large circular chalaza below. Around the hilum (top of figure) portions of the endocarp still remain. × 1·4.

10.—The same, opposite side, showing the raphe (*r*). × 1·5.

Laurocarpum sp. 12, p. 237. V. 22382.

11.—Endocarp, crushed. The columnar coat remains around the funicular aperture (*a*); the character of the cells can be seen both superficially and in section. Where the columnar coat is removed the testa is seen. × 2·1.

12.—The same, looking on to the funicular aperture (*a*). × 2·1.

Laurocarpum sp. 13, p. 237. V. 22383.

13.—Fruit, wanting the epicarp. The attachment is a knob on the surface near the base of the figure. × 1.

14.—The same in approximately longitudinal section, the attachment being at the base. Note the coats, thick mesocarp (*m*), thin endocarp (*e*), within which is the testa. × 1·44.

Laurocarpum sp. 14, p. 238. V. 22385.

15.—Seed with remains of locule-cast adhering over the upper portion. In some of the furrows on the locule-cast are small fragments of endocarp. Below is a portion of the chalaza. × 1·6.

16.—The same, apex, showing the aperture (*a*) for the funicle. × 1·6.

Laurocarpum sp. 15, p. 238. V. 22386.

17.—Broken berry showing the endocarp lying within the mesocarp; the columnar wall of the endocarp covers most of the surface, but over the middle it is chipped away showing the locule-cast. × 1·3.

FIG.

18.—Endocarp of the same removed from the mesocarp; most of the columnar coat is chipped off, exposing the locule-cast. The aperture for the funicle at (*a*) is obscure. × 2·4.

Laurocarpum sp. 16, p. 239. V. 22387.

19.—Crushed locule-cast and seed, with fragments of the columnar coat of the endocarp and remains of the testa adhering. × 2·87.

Laurocarpum sp. 17, p. 240. V. 22391.

20.—A berry, apex, with remains of the mesocarp; at the apex the endocarp is exposed, and, beneath that, the seed. × 1·1.

Laurocarpum sp. 18, p. 240. V. 22392.

21.—Seed-cast, with remains of testa, also of endocarp, around the hilum (top of figure). Above is the groove between the cotyledons; the large chalaza occupies almost the whole length of the seed. × 1·4. Herne Bay.

Laurocarpum sp. 19, p. 241. V. 22393.

22.—Seed-cast with remains of testa and a minute fragment of the endocarp at the hilar end (top of figure). Note the large shining chalaza. × 1·28.

? Laurocarpum sp. 21, p. 243. V. 22413.

23.—Endocarp showing a conspicuous network of fibres on its surface. × 2·1.

24.—The same, opposite side. Note the fragment of exocarp, with dimpled surface, near the base on the left. × 1·5.

? Laurocarpum sp. 22, p. 244. V. 22414.

25.—Fruit, exterior. × 1.

26.—Pericarp removed from the same. Note the smooth edge of the basal aperture, probably indicating a swollen peduncle. × 1.

27.—Part of the seed from the same. × 1.

? Lauraceae sp. 1, p. 244. V. 22415.

28.—Internal cast of seed. × 3.

? Lauraceae sp. 2, p. 245. V. 22416.

29.—Internal cast of seed with testa adhering above. × 1·3. Herne Bay.

Saxifragispermum spinosissimum n. gen. & sp., p. 245. V. 22417.

30.—Fruit, side view. The seeds show through the abraded pericarp. × 3.

31.—The same fruit, one end. × 5.

32.—The same, longitudinal section showing peripheral arrangement of seeds and character of the fibres which fill the locule. Two seeds on the left show the circular chalaza directed inwards. × 8·5.

33.—Part of the same in longitudinal section to show, on the marginal seed to the right, the apiculate cast of the micropyle directed outwards. × 8·5.

34.—Part of a transverse section of the same to show peripheral arrangement of seeds; four seeds are grouped around a placenta near the top of the figure. × 6.

35.—Part of fig. 32 magnified to show the fibres and spinescent seeds (the spines are best seen on the right side of the sectioned seed). × 19.

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LAURACEAE, SAXIFRAGACEAE

PLATE IX

Explanation of Plate IX

FIG. *Protaltingia europaea* n. gen. & sp., p. 247. V. 22419.

1.—Fruiting head. × 1·5.

2.—A portion of the same to show two of the small areoles, on the left, in superficial view. In the lower the two black crescents mark the position of the worn-down gaping carpel walls, the lenticular mass of pyrites being the infilling of the space between them. In the upper areole the wall is incomplete on the left, the right cavity is filled by the cellular remains of the carpel, the left cavity being black and empty. The two pairs of small black objects marked (*s*) we interpret as abortive seeds, the upper pair being bisected by the fracture of the areole wall. × 3.

3.—Part of a longitudinal section through the same showing the central axis, and on the right a single fruitlet (two antero-posterior carpels) lying within one of the areoles. × 3.

4.—Part of the same, a single carpel as seen on the surface of the fruit. Abrasion has extended to the level of the septum which lies at the base of the figure; the two crescents therefore represent but half of the big crescents seen in fig. 2. The fellow carpel, with a corresponding pair of small crescents, is cut off by the base of the figure. × 6·5.

5.—A single fruitlet (consisting of a pair of carpels). The septum is bisected vertically and the placenta is at its upper end. Note the coarse fibres forming the endocarp. × 6·5.

Hamamelidaceae Genus ?, p. 249. V. 22420.

6.—A seed. The hilum lay on the truncate surface at the top of the figure, the raphe on the broad marginal band arising from this surface, seen on the right. × 6·5.

Wetherellia variabilis Bowerbank, p. 251.

7.—A relatively unworn fruit tilted to show the apex. × 1·1. V. 22421.

8.—Base of a much worn five-loculed fruit, showing the locule-casts within. × 1·1. V. 22422.

9.—Side of an ovoid three-loculed fruit; the ridge of infiltrated pyrites marks a plane of septicidal dehiscence. × 1·1. V. 22423.

10.—A four-loculed fruit, showing planes of loculicidal as well as of septicidal dehiscence. × 1·1. V. 22424.

11.—The worn base of a three-loculed fruit, from which the locule-casts have fallen. × 1·1. V. 22425.

12.—The worn base of a two-loculed fruit; one locule-cast has fallen, the other remains in the locule. × 1·1. V. 22426.

13.—A coccus from a two-loculed fruit, ventral, showing the surface of the septum (very little worn). × 1. V. 22427.

14.—A coccus from a two-loculed fruit, ventral, abraded so that the locule-cast protrudes through the worn septum. × 1. V. 22428.

15.—A coccus from a two-loculed fruit more abraded than the last so that the locule-cast has fallen. Ventral. × 1. V. 22429.

16.—A coccus from a multilocular fruit showing the faceted ventral surface with the locule-cast still lying within the abraded carpel. × 1·1. V. 22430.

17.—A fruit fractured loculicidally to show the mode of placentation; the casts of the funicles are seen arising from the median axis and connecting with the locule-casts (not seeds). × 1. V. 22431.

FIG.

18.—A fruit, fractured loculicidally (incomplete on the left), showing the long arched funicles arising sub-apically from the axis. The locule-casts are sectioned longitudinally, exposing the pendulous seeds. (The dark patch in the middle of the seed-cast on the right is a mass of crystalline pyrites occupying a cavity in the incompletely pyritized seed.) The figure shows very clearly, to the right of the axis, the smooth surface of the plane of loculicidal dehiscence beyond the limit of the seed and locule. × 5·5. V. 22432.

19.—Half of a coccus split loculicidally, showing the internal cast of a seed covered, near the base, by the testa. On the right, where the testa has been chipped away, is the raphe (*r*). × 5·5. V. 22434.

20.—A seed with remains of the testa. The slight mucro (*ch*) at the base of the figure is the chalaza, the hilum and micropyle are at the pointed end (top of figure). × 8. V. 22435.

21.—The internal cast of a seed (apex only figured) showing the chalaza with cells arranged concentrically around it. × 19. V. 22436.

22.—Part of a coccus fractured transversely to show the coarse angular cells of the wall. × 9. V. 22433.

Decaplatyspermum Bowerbanki n. gen. & sp., p. 256. V. 22447.

23.—A much abraded fruit showing seeds embedded in pyrites. Both septa (*st*) and seeds (*s*) are carbonaceous and appear as thin black longitudinal lines. The septa can be distinguished by their continuity with the axis or other parts of the carpel wall. The seeds, seen in longitudinal section owing to abrasion, are asymmetrically displaced within the pyrites which fills the locules, the right-hand seed in the figure (*s3*) having a thick mass of light-coloured pyrites on its right and a thin mass on its left. The next seed (*s4*) has the reverse; the light-coloured pyrites mass in this locule occupies the centre of the figure. The third seed (*s5*) appears thicker, and occupies more of the locule-cavity because abrasion has been carried nearer to the axis. × 3.

24.—The same, base. The seeds are numbered as in the foregoing. × 3.

25.—A fragment broken from the right side of the specimen as seen in fig. 24. The numbering is the same. The seeds *s1* and *s2* are inflated. × 3.

26.—The reverse of the same fragment, showing the longitudinal section through the thick axis. × 3.

27.—A fragment of the same fruit, showing the impression and remains of a seed on the pyrites cast of a locule; part of the axis of the fruit is seen on the right. × 3.

28.—The impression and remains of another seed on a locule-cast. It shows the slightly hooked hilar end (at the top on the left of the figure). × 3.

29.—An impression of a seed (imperfect at the top) on a locule-cast, showing the transverse alignment of the cells and the puckerings of the testa. × 6.

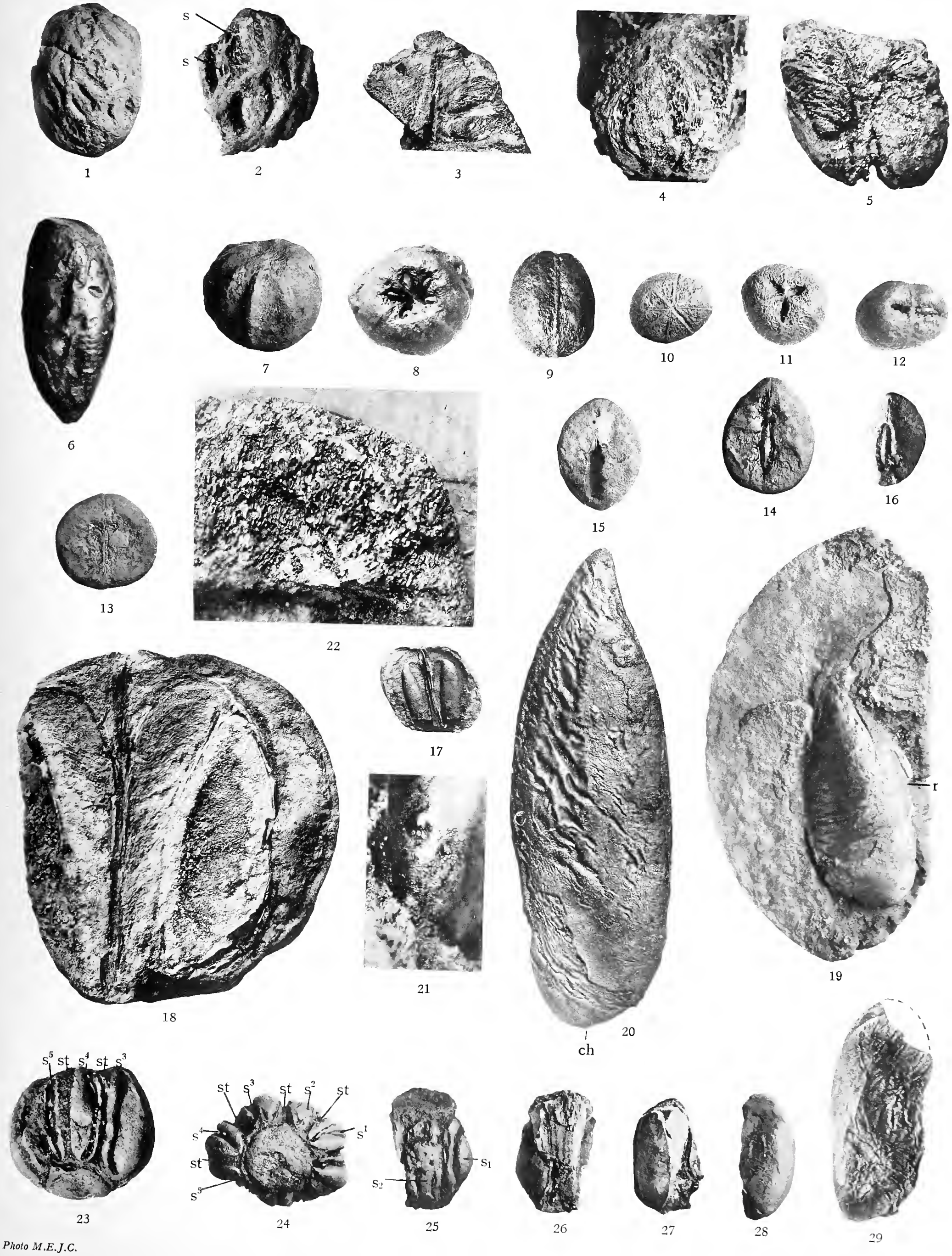

Photo M.E.J.C.

HAMAMELIDACEAE to LINACEAE

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PLATE X

Explanation of Plate X

FIG. *Canticarya sheppeyensis* n. gen. & sp., p. 258.

1.—Seed, side view. The ventral margin is to the right. The circular chalaza (*ch*) is just distinguishable in profile at the base of the figure. × 6. V. 22448.

2.—The reverse of the seed in fig. 1, with remains of carpel still adhering. The ventral margin (originally united to the axis of the fruit) is turned to the left. The oblique fibres of the endocarp form an adherent patch over the middle of the seed. × 6.

3.—The internal cast of a carpel, showing the placental scar (*p*). × 2·7. V. 22449.

4.—A locule-cast with much of the carpel wall remaining (on the left and below). A pale longitudinal ridge of pyrites lies between the carpel valves. × 2·7. V. 22450.

5.—The chalazal region of a seed, showing the coats of the testa; the remains of the carpel still adhere to the ventral margin of the seed (top of the figure). The raphe (*r*) is an obscure longitudinal band lying between the chalaza (*ch*) and the ventral margin. × 6·6. V. 22451.

Canticarya ventricosa n. sp., p. 259.

6.—A seed, with remains of the endocarp adhering, dorsal side. The oblique fibres of the endocarp diverge from the median line; impressions of the polygonal cells of the testa are seen on the locule-cast. The seed-cast is exposed at the top left of the figure, where locule-cast and endocarp are chipped away. × 6·6. V. 22456.

7.—A much polished and abraded carpel, showing the ventricose form and straight truncate ventral margin. × 2·7. V.22457.

Canticarya ovalis n. sp., p. 260. V. 22462.

8.—Carpel, side view. The seed can be seen within the broken pericarp. The chalaza (hidden by the pericarp) is at the base of the figure. The ventral margin is on the right. × 2·8.

9.—The same, with the broken pericarp and testa partly removed, to show the seed-cast. The chalaza is in shadow at the base of this cast. Note the thick pericarp. × 2·8.

Canticarya gracilis n. sp., p. 261. V. 22464.

10.—A locule-cast with remains of the pericarp, side; the ventral margin is to the right, (*ch*) marks the position of the chalaza. × 6·6.

Shrubsolea Jenkinsi n. gen. & sp., p. 262. V. 22465.

11.—Seed, ventral margin, with the hilar scar at the top. × 2·8.

12.—The same, side view, with the ventral margin to the left. × 2·8. Herne Bay.

Eozanthoxylon glandulosum n. gen. & sp., p. 263. V. 22466.

13.—A capsule, side view, ventral margin to the right; dorsal margin partly broken. Note glandular pits on the surface. The seed-cast shows as a dark body beneath the broken dorsal margin of the pericarp. The chalaza is at (*ch*). × 2·8.

14.—The same, dorsal. The seed-cast lies within. The chalaza is at the middle of the median ridge on the seed-cast. × 2·8.

Clausenispermum dubium n. gen. & sp., p. 264.

15.—Seed, side view; along the ventral margin (on the left) lies the raphe (a single band of fibres); from a point near the base of the figure, it turns back and branches in the direction of the hilar end of the seed (top of figure). × 6·7. V. 22467.

16.—Another seed, broken at the hilar end to show the internal cast. × 6·5. V. 22468.

FIG. *Caxtonia glandulosa* n. gen. & sp., p. 265.

17.—A fruit, fractured to show the internal cast of the seed. The pericarp is seen in section; at the base of the seed on the left are some of the secreting cells of the testa. × 3. V. 22469.

18.—A detached seed showing the coarse secreting cells of the testa. × 6·5. V. 22470.

19.—Base of seed showing chalaza, with transverse ridge of pyrites. × 6·5. V. 22471.

Caxtonia ? rutacaeformis n. sp., p. 266. V. 22476.

20.—A carpel, fractured, with a seed lying in the locule, showing large testa cells. × 2·8.

21.—The counterpart with remains of the testa adhering. × 2·8.

22.—The same seed, removed from the carpel. The chalaza is at the base of the figure. × 2·8.

23.—The same, looking on to the chalaza. × 2·8.

Tricarpellites communis Bowerbank, p. 268.

24.—An endocarp, side view, showing two of the three carpels; abraded so that the outline of the locule-casts can be seen obscurely. The carpels are beginning to separate. × 2. (Specimen now completely decayed.)

25.—The same, apex, showing the three carpels and the three-lobed apex of the axis between them. × 2.

26.—The base of another endocarp showing the three carpels. The axis at the base is simple, not lobed. × 2. (Specimen now completely decayed.)

27.—Apex of an abraded endocarp from which one carpel has been detached (top of the figure); note the lobed apex of the axis. The germination valves have come away so that the locules are partly exposed. × 2. (Specimen now completely decayed.)

28.—Detached carpel, dorsal surface, with the germination valve removed at the apex, showing the locule-cast within still covered by the innermost layers of the endocarp. Note the finished edges where the valve has come away. × 6. V. 22477.

29.—The valve (inner face) removed from the preceding. The apex is broken. × 6.

30.—A second carpel belonging to V. 22477, ventral. Note the impression of the axis broadening above, and the median scar (*p*) which marks the passage of fibres from axis to placenta. × 6.

31.—Two carpels (the third facing the camera has been removed). The axis widens upwards. × 2. (Specimen now completely decayed.)

32.—A detached carpel, ventral face, with the upper part of the ventral wall removed, showing the locule-cast (reproducing the form of the seed) within. The placental scar (*p*) corresponds in position to the hilum of the seed. × 3. V. 22478.

33.—Locule-cast, dorsal, showing the faceting beneath the valve. Notice at the limit of the faceted area the "curved line" mentioned by Bowerbank. A portion of the inner part of the endocarp adheres below. × 6. V. 22479.

34.—The same cast, ventral. Note the median angle above the level of the placentas, and the indication of two placentas shown by two patches of carbonaceous substance one on each side where the angle terminates. × 6.

35.—A portion of a locule-cast with the middle layer of the endocarp adhering (the "beautifully reticulated layer" of Bowerbank). × 6. (Specimen now completely decayed.)

36.—Internal cast of a seed, ventral side, showing the ob-cordate chalazal scar. The small dark scar (*h*) marks the position of the hilum. × 8. V. 22480.

37.—The same seed-cast, dorsal side. × 8.

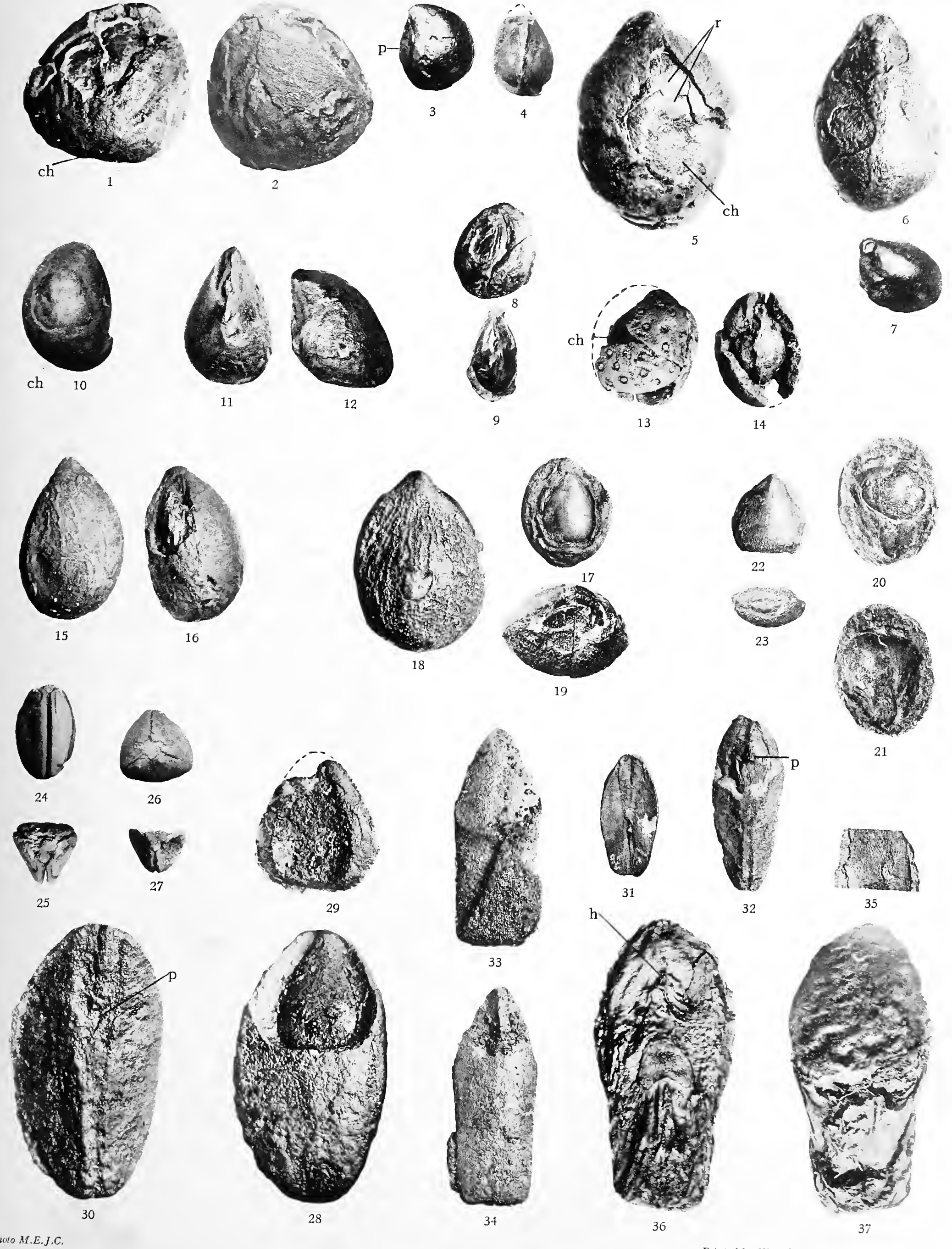

Photo M.E.J.C.

RUTACEAE to BURSERACEAE

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PLATE XI

Explanation of Plate XI

FIG. *Protocommiphora europaea* n. gen. & sp., p. 273.

1.—A two-loculed endocarp, dorsal view of the fertile carpel. Part of the carpel wall is broken away at the base, showing the locule-cast. × 5·5. V. 22484.

2.—The same, opposite side; the germination valve has come away, showing the cast of the abortive locule with the impressions of two abortive collateral seeds. × 5·5.

3.—The same, after removal of that part of the endocarp and the abortive locule delimited in fig. 2 by an irregular line of fracture near the apex of the abortive locule-cast, so as to expose the ventral side of the fertile locule. A pair of placentas is seen at (*p*). One seed only has developed and its cast can be seen at (*s*), where the locule-cast has been chipped away. The oblique band (*ch*) on the right is part of the chalaza. × 5·5.

4.—Another locule-cast, ventral. The placenta is at the termination of the vertical ridge. × 2·7. V. 22486.

5.—Another locule-cast, dorsal. × 2·6. V. 22487.

6.—An endocarp, fractured longitudinally to show the internal cast of the seed (ventral face) lying in the locule. The curved fibrous band is the chalaza. × 2·4. V. 22488.

7.—Counterpart of the last, showing the external impression of the seed (ventral face) on the locule-cast. Owing to the thinness of the testa, the impression of the relatively thick chalazal band can be seen, although the fibres are actually on the inner surface of the seed. × 2·4.

Bursericarpum angulatum n. gen. & sp., p. 275. V. 22491.

8.—A detached carpel, ventral. Note the median placenta (*p*) on the ventral angle. × 3.

9.—Another carpel from the same fruit, showing one of the ventral faces. Note the placenta (*p*) and the curved band of fibres associated with it. × 3.

10.—A third carpel from the same fruit, dissected to show the locule-cast, dorsal surface. The apex is broken. Note the curved line, which may correspond, as in other Burseraceae, with the limits of a germination valve. × 3.

Toona sulcata (Bowerbank), p. 276.

11.—A fruit, side view, showing the remains of the peduncle (cf. *Cupressinites sulcatus* Bowerbank). × 1·5. V. 22497.

12.—A five-loculed fruit with pericarp preserved. The specimen has split septicidally (wide deep grooves) and loculicidally (narrow grooves alternating with the last). × 2 approx. V. 22492.

FIG.

13.—The same fruit fractured longitudinally, showing the axis, septa (somewhat puckered) and the thickness of the pericarp. × 3.

14.—A fruit with pericarp preserved (cf. *Cupressinites semiplotus* Bowerb.). × 1·5. V. 22498.

15.—Fruit, apex, abraded so as to show the columella and the impressions of the tips of the overlapping wings of the seeds. × 2·7. V. 22493.

16.—An abraded fruit, showing locule-casts with impressions of the overlapping seeds. × 2 approx. V. 22494.

17.—The same, another view to show the winged seeds more in profile (right-hand locule). × 2 approx.

18.—Two overlapping seeds with remains of testa. The bodies of the seeds (*s*) are towards the base of the figure, where both are imperfect. The long raphe of the left seed is marked by an oblique fibre (*r*). The upper portion of the figure is occupied by the impression of the wing of this seed. × 6·7. V. 22495.

19.—Part of the internal cast of a seed showing the chalaza (*ch*). The seed lies in a locule-cast. × 6·7. V. 22496.

Melicarya variabilis n. gen. & sp., p. 280.

20.—A nine-loculed fruit, much abraded, showing the locule-casts protruding, side. × 2·7. V. 22501.

21.—The same, base. × 2·7.

22.—The same fruit sectioned longitudinally. The fusiform axis is now replaced by pyrites (white). On the left an abortive locule and seed are seen in section; the short thin funicle (*f*) indicates the position of the placenta. In section on the left is one of the small apical canals. × 6·5.

23.—Fruit, longitudinally sectioned, showing a developed locule on the right, with the locule-cast in place. × 7. V. 22503.

24.—A median longitudinal section through an imperfect fruit, showing remains of the fibrous axis. × 6·7. V. 22502.

Meliaceae ? Genus ?, p. 282. V. 22506.

25.—Imperfect fruit with remains of the pericarp at the base. × 2·75.

26.—The right-hand fragment seen in fig. 25, looking on to the perpendicular plane of fracture. Consequently it represents half of a median longitudinal section. The dark vertical bands are remains of seeds and wings. × 6·5.

27.—The left side of the upper left-hand fragment (fig. 25) viewed obliquely from the rear, showing a seed lying within the remains of the fruit. The chalaza (*ch*) is a small round black spot in the middle of a narrow oblique black band. × 6·5.

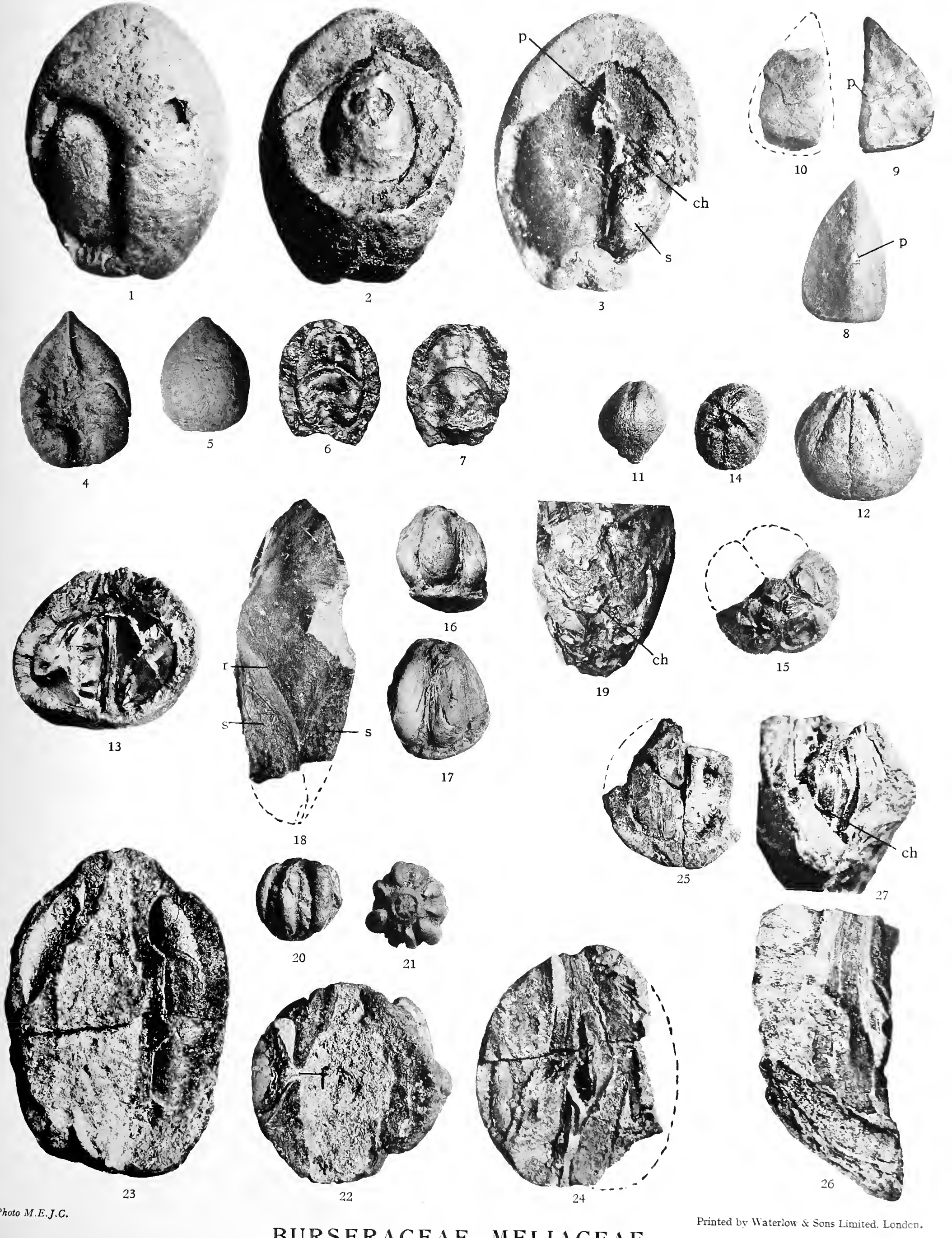

Photo M.E.J.C.

BURSERACEAE, MELIACEAE

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PLATE XII

PLATE XIII

Explanation of Plate XIII

FIG.

Euphorbiospermum ambiguum n. sp., p. 295.

1.—Seed, ventral. × 6·5. V. 22527.

2.—The same, side, to show the angle of faceting. × 2·8.

Euphorbiospermum latum n. sp., p. 295.

3.—Seed-cast, ventral. Note the deep hilar depressions. × 6·6. V. 22529.

4.—The same, side, showing the angle of faceting. × 2·8.

Euphorbiospermum crassitestum n. sp., p. 296.

5.—Seed-cast, ventral. × 2·8. V. 22531.

6.—The same, side, showing the angle of faceting. × 2·8.

7.—Another seed, with the testa preserved in parts, ventral. × 2·8. V. 22532.

Euphorbiaceae ? Genus ? p. 297.

8.—Dorsal face of a coccus. × 6·5. Harefield. V. 22533.

9.—The same coccus split loculicidally. × 6·6.

Dracontomelon subglobosum n. sp., p. 299.

10.—A five-loculed endocarp, side. × 2. V. 22534.

11.—Another endocarp, apex, with five apertures leading to the locules closed by plugs, or with locule-casts protruding. × 2. V. 22535.

12.—Another endocarp. Some of the locule-casts have fallen out. The black furrow across the lower right-hand cast is the impression of the funicle. × 2. V. 22536.

13.—Another endocarp, base. × 2. V. 22537.

14.—Another endocarp, apex, with worn fibrous surface. From the top left-hand locule the locule-cast has fallen. Abrasion has exposed the seed-casts; the rim surrounding these is in part testa and in part pyrites. × 3. (Specimen now decayed.)

15.—Another much abraded endocarp showing the locule-casts protruding. × 2. V. 22538.

16.—A longitudinal fracture through another endocarp, exposing a locule-cast (*l*) and an apical plug (*p*), also one of the small paired apertures (*ap*) in section. × 3. V. 22539.

17.—An endocarp fractured transversely, showing the locules filled with white pyrites and surrounded by hard fibrous walls, the interspaces between them being filled with parenchyma. The left-hand locule contains a seed-cast (*s*). × 6·6. V. 22540.

18.—A germination plug, inner face, detached from an endocarp. × 14. V. 22541.

19.—A seed, side. The thick end lay beneath the plug; the hilum is on the upper margin, and the circular chalaza (*ch*) is seen in profile on the concave margin. × 6·6. V. 22542.

Dracontomelon minimum n. sp., p. 302.

20.—An endocarp, apex, with five locules; the plugs are seen around the periphery of the figure. × 2. V. 22546.

FIG.

21.—The same, base. × 2·8.

22.—The same, side. × 2·8.

23.—Another endocarp, showing locules above and two of the small paired holes below. × 2·8. V. 22547.

24.—Part of an endocarp, fractured longitudinally to expose a seed. The hilar margin of the seed is broken away. The large circular chalaza (*ch*) is seen in profile as a semicircular black scar to the right of the base. × 5. V. 22548.

Pseudosclerocarya lentiformis n. gen. & sp., p. 303.

25.—An endocarp, apex, showing the fibrous structure, and the large plugs closing the locules. × 1·75. V. 22550.

26.—The same, base. The small basal apertures (*ap*) are scarcely distinguishable in the figure. × 1·75.

27.—The same, side. × 1·7.

28.—An endocarp fractured longitudinally to show the locule-cast (in form similar to the seed). × 3. V. 22551.

Pseudosclerocarya subalata n. sp., p. 304.

29.—Endocarp, apex, showing obscurely the apertures to some of the locules closed by plugs (*p*). × 1·75. V. 22553.

30.—The same, base. × 1·75.

31.—The same, side. × 1·7.

Spondias sheppeyensis n. sp., p. 305.

32.—A worn endocarp, side, showing the apertures above, and a locule-cast (*lc*) protruding below. × 1·8. V. 22554.

33.—The same, fractured longitudinally. Part of a seed (white) is exposed within the left-hand locule. × 1·8.

34.—The same endocarp, fractured transversely, showing the five locules. × 1·8.

Spondicarya trilocularis n. gen. & sp., p. 306.

35.—A worn endocarp with large locule-cast protruding (middle of figure). The plug covered the large dark oval hilar area (*h*) on the left, above. × 6·6. V. 22555.

36.—A seed from the same endocarp, side, showing the large circular chalaza, in profile, as a semicircular patch (*ch*) at the middle of the convex margin. × 6·6.

Odina Jenkinsi n. sp., p. 308.

37.—Endocarp, side, showing large hollows, filled with parenchyma, between thick massive cords of gnarled fibres. × 6·5. Herne Bay. V. 22556.

38.—The same, endocarp removed from the dorsal margin (right margin in fig. 37) to expose the seed. The large chalaza (*ch*) is seen in profile on this margin. × 6·5.

39.—The same, looking on to the dorsal margin. The circular chalaza is seen sectioned by the crack. Note the thin testa, in section, and the thick endocarp wall (light grey). × 6·7.

40.—A seed probably referable to this species. The large chalaza is at the middle of the concave margin. × 6·6. V. 22557.

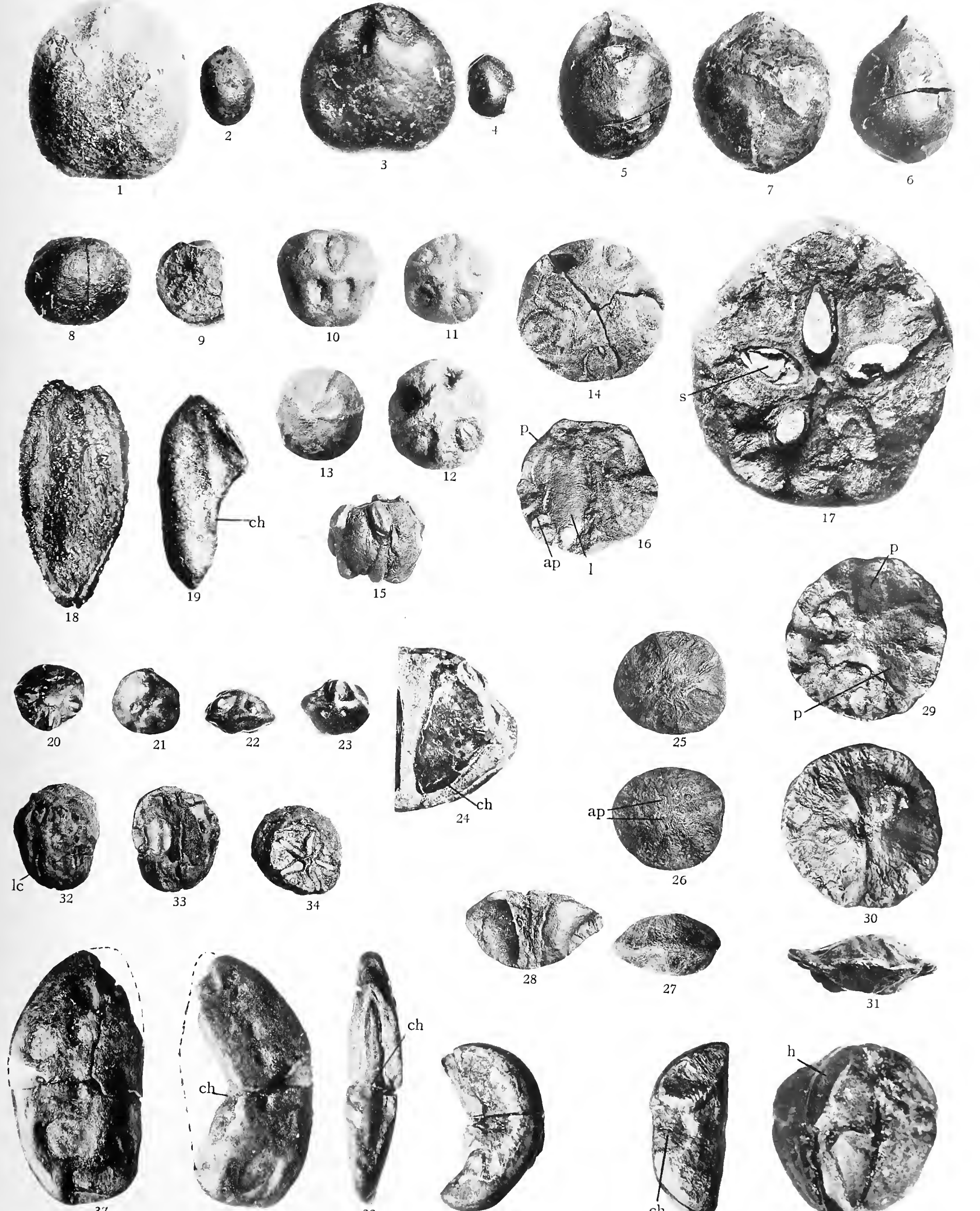

Photo M.E.J.C.

EUPHORBIACEAE, ANACARDIACEAE

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PLATE XIV

Explanation of Plate XIV

FIG.

Odina europaea n. sp., p. 309.

1.—Endocarp, side. × 6·6. V. 22558.

2.—The same, viewed approximately at right angles to fig. 1. The carpel wall has been partly removed to expose a seed (*s*). The chalaza is a dark semicircular patch (*ch*) to the left of the white line. × 6·6.

3.—The same, fractured transversely. One of the two locules (*l*, *l*) is abortive. × 6·5.

4.—Another endocarp, worn at the apex so that the two locule-casts (*l*, *l*) protrude. × 2·8. V. 22559.

Odina ? subreniformis n. sp., p. 310.

5.—Endocarp, side. × 1·8. V. 22560.

6.—The same, dorsal (left side in fig. 5). × 1·8.

7.—The same, after irregular longitudinal fracture, showing the locule. × 1·8.

8.—The counterpart of fig. 7, showing the seed lying in the locule. × 1·8.

Xylocarya trilocularis n. gen. & sp., p. 312. V. 22561.

9.—Endocarp, side. The best developed locule lies beneath the middle of the figure. The two smaller locules (*l*) are marginal right and left (cf. fig. 12 in which the upper margin is the sectioned surface seen in fig. 9). × 2·8.

10.—The same, reverse side (lower margin in fig. 12). The smaller locule-casts (*l*) are seen, right and left, on the margin. × 2·8.

11.—The right side of fig. 9 (left fig. 10) viewed edgeways. The smooth rounded contour seen in fig. 9 lies to the left of the figure. The longitudinal ridge extending nearly the length of the figure is the locule-cast (*l*, narrow as seen in this view, cf. left locule in fig. 12). The irregular marginal ridge is that of the remains of the endocarp, seen at the top left in fig. 10. × 2·8.

12.—The upper half of the specimen, seen in transverse section. The developed locule (*dl*) is median, the two others (*l*) marginal below. × 2·8.

Anacardiaceae (Section Spondieae) Genus ?, p. 313. V. 22562.

13.—A much worn endocarp, side. The narrow dorsal margin of the fertile locule (*fl*) is partly exposed as a rounded ridge to the left of the crack in the upper part of the figure. × 6·6.

14.—The same, reverse. The endocarp is here worn into a narrow vertical groove in which the ventral margin of the fertile locule is exposed. The abortive locules cannot be seen; they lie within the endocarp to the right and left of the fertile locule. × 6·6.

15.—The same, fractured longitudinally (see crack in fig. 13). The locule-cast has the curved form characteristic of locules and seeds of the section Spondieae. The hilum is on the broad upper margin; the dorsal margin of the seed lies to the left. × 6·6.

Lobaticarpum variabile n. gen. & sp., p. 314.

16.—A broken fruit showing the very thick pericarp, with two locule-casts (*lc*). The perfect right-hand cast shows the funicle (*f*) as a white streak of pyrites at the top of the figure; the left is fractured and is seen in section. × 3. V. 22563.

17.—Another fruit, fractured so as to show a pendulous anatropous seed in a locule. The funicle (*f*) is seen as a vertical dark line, the hilum (*h*) lies to the left, and the marginal chalaza (*ch*) is not actually shown in the figure. The large excrescence on the right is one of the "floats" (cf. figs. 18–20). × 3. V. 22564.

18.—A three-loculed fruit, base. × 1. V. 22565.

FIG.

19.—The same, apex, worn so as to expose the three locules, the upper as a narrow dark streak, the right and left as grey streaks radiating from the centre, between the large globular "floats," now filled with pyrites. × 1.

20.—A much worn fruit, apex, showing the stylar scar, and the pyritized "floats" exposed by abrasion of the pericarp. × 1. V. 22566.

Anacardiaceae ? Genus ?, p. 316.

21.—A fruit, side. × 2·8. V. 22575. Herne Bay.

22.—The same, with the lateral fragment removed, seen edgeways, showing the locule-cast. (Inverted.) × 2·8.

Cathispermum pulchrum n. gen. & sp., p. 317.

23.—A broken fruit, to show the form. × 1·8. V. 22577.

24.—Part of the same fruit, showing two broken seeds. × 6·6.

25.—The counterpart of fig. 24. × 6·6.

26.—A seed from the holotype (now decayed). The body of the seed is above, and the basi-lateral wing (broken along its right side) is below. The micropyle (*m*) is a small sunk scar seen in profile. × 4·8. V. 22576.

27.—Seed from the holotype with wing and testa preserved. × 12.

28.—Another seed from the holotype, from which the testa is abraded over the body but preserved over the wing. The chalaza is at (*ch*). × 12.

Canticarpum celastroides n. gen. & sp., p. 320. V. 22578.

29.—Fruit, exterior, distorted, and much worn at the apex (top of figure). × 2·8.

30.—The same, apex, abraded so as to expose three locule-casts. × 2·8.

31.—A fragment removed by an oblique tangential fracture. Two locules are exposed right and left. Owing to the direction of fracture the seeds appear to lie one above the other, but actually they lie side by side. × 6·6.

32.—The counterpart. The third locule lies behind, out of view. × 6·6.

33.—The seed on the lower right in fig. 32, isolated. The coat of polygonal cells is largely broken away exposing the inner coat of the testa. × 6·5.

Iodes corniculata n. sp., p. 323.

34.—Endocarp, side. × 3·2. V. 22579.

35.—The same, funicular margin. The funicular canal is exposed in its lower half by the fracture of its outer wall. × 3·1.

36.—The same, opposite margin. × 3·1.

37.—Endocarp, showing how the outer layers peel away as the result of fossilization and decay. × 3·1. V. 22580.

38.—An abraded endocarp. × 2·8. V. 22581.

39.—Another specimen with more of the endocarp removed. × 2·8. V. 22582.

40.—A locule-cast. The knob is the placental end of the funicle with adhering pyrites. × 2·8. V. 22583.

41.—A seed with some of the locule-cast adhering (top and left) around the placenta. Note the impressions of gas bubbles formed during fossilization. × 2·8. V. 22584.

42.—Internal cast of seed. The differentiated area at the top marks the micropyle and hilum. The longitudinal band of fibres is the raphe (*r*), the chalaza being at the bottom of the figure. × 2·8. V. 22585.

43.—The same, looking on to the hilum (*h*) and the micropyle (*m*). × 6.

Photo M.E.J.C.

ANACARDIACEAE to ICACINACEAE

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PLATE XV

Explanation of Plate XV

FIG.

Iodes multireticulata n. sp., p. 325.

1.—Endocarp, side. × 2·76. V. 22589.

2.—An elongate specimen with remains of the funicular ridge (*f*) and stylar canal (*st*) at the top. × 2·8. V. 22590.

3.—The same, looking on to the transverse opening of the stylar canal. × 3.

4.—Another broader endocarp with remains of the funicle at the top. × 3·1. V. 22591.

5.—Locule-cast of a narrow ovate endocarp. × 3·1. V. 22592.

6.—Locule-cast of an endocarp which has split for germination. × 3·1. V. 22593.

7.—Impression on a locule-cast of the papillae of the locule-lining. × 13. V. 22594.

8.—Internal cast of a seed (below), showing raphe (*r*) and chalaza (*ch*). Above, the seed is covered by the adherent locule-cast. × 2·8. V. 22595.

9.—A locule-cast, showing the rare inflated form, base. × 3·1. V. 22596.

10.—A locule-cast, showing the rare bilobed form, apex. × 3·1. V. 22597.

11.—The same, side. The remains of the funicle (*f*) are seen at the top. × 3·1.

Iodes eocenica n. sp., p. 328.

12.—A slightly broken endocarp, side. × 2. V. 22615.

13.—The same, apex. One of the " horns " is seen to the right of the median groove. The other lies in the shadow to the left.

14.—The same, internal seed-cast with remains of testa. The raphe (*r*) is a narrow, dark longitudinal groove. The hilum (*h*) is a circular scar (top of figure). × 1·5.

15.—Specimen with endocarp partly removed to expose the locule-cast. Along the top left margin the funicular canal (*f*) has been broken into. The conical apex of the locule-cast corresponds with the stylar canal (*st*). × 1·5. V. 22616.

Iodes sp., p. 330.

16.—Locule-cast (in calcite), side. × 2·8. Assington, Suffolk. V. 22618.

17.—The same, funicular margin. The scar of the placenta (*p*) is seen at the top. × 2·8.

Sphaeriodes ventricosa (Bowerbank) n. gen., p. 331.

18.—An abraded endocarp with the funicular canal (*f*) exposed on the right. × 1·6. V. 22619.

19.—The same, looking on to the funicular canal. Note the forking at the apex where fibres are given off to the apical " horns." × 1·7.

20.—An endocarp (broken at the apex) showing the rugose exterior (rarely preserved). × 1·5. V. 22620.

21.—A more abraded endocarp, side. × 1·5. V. 22621.

22.—The same endocarp, apex. × 1·5.

23.—A seed, chalazal end. The chalaza (*ch*) is a small circular scar. × 1·8. V. 22622.

Palaeophytocrene foveolata n. gen. & sp., p. 333.

24.—Endocarp, worn in parts so that the locule-cast (*lc*), with more pronounced sculpture, is exposed. × 1·5. V. 22633.

FIG.

25.—The reverse of the same, showing the thickness of the endocarp in section (right margin). × 1·6.

26.—Endocarp, exterior, much obscured by pyrites. × 1·5. V. 22634.

27.—Locule-cast with part of the endocarp adhering. Remains of the style are seen at the apex. × 1·5. V. 22635.

28.—The same, margin. × 1·5.

29.—A locule-cast with endocarp completely abraded. × 1·5. V. 22636.

30.—A locule-cast with the inner layers of the endocarp preserved. On the left and at the top, the broken locule-cast reveals the crumpled seed. × 2·1. V. 22637.

31.—Stellate groups of cells on an inner layer of the endocarp, same specimen. × 13.

32.—Testa-cells of the seed from the same specimen. × 13.

Palaeophytocrene foveolata var. *minima* nov., p. 335. V. 22644.

33.—Locule-cast, worn so as to show traces of the testa within. × 1·6.

Palaeophytocrene ambigua n. sp., p. 336. V. 22646.

34.—Locule-cast with remains of the endocarp below. The pits in the latter are smaller than those in the cast, and are mostly filled with pyrites. × 1·5.

Stizocarya communis n. gen. & sp., p. 336.

35.—An endocarp, fractured to expose the locule-cast (*l*) covered by the inner layer of the endocarp. The small white dots are the pyritized inner ends of hairs which arise from the outer surface of this layer and penetrate the outer wall of the endocarp. On the lower right the seed (*s*) is exposed. × 1·8. V. 22647.

36.—An endocarp, apex, worn so that the funicle (*f*) is exposed The remains of hairs are seen as small dots on the surface. Note the pair of small apical " horns." × 1·8. V. 22648.

37.—An endocarp, apex, more worn than the last. Note the apical " horns." × 1·8. V. 22649.

38.—A locule-cast with remains of endocarp, apical margin with placenta (*p*). × 1·8. V. 22650.

39.—A locule-cast, side, covered by the inner layer of the endocarp on which the hair-bases form small papillae. × 1·8. V. 22651.

40.—Internal cast of seed with remains of testa (middle of figure), apex, surrounded by remains of the locule-cast, on the surface of which are pyritized hair-bases. Aligned as in figs. 36–38. The upper circular scar is the micropyle (*m*); the lower median scar is the hilum (*h*) from which the raphe (*r*) arises (black horizontal streak). × 4·7. V. 22652.

41.—An endocarp, fractured to show the structure of the wall. The position of the hairs is indicated by black remains in the white pyrites envelope which covers the actual endocarp. × 2·7. V. 22653.

42.—The inner layer of the endocarp (formed of digitate cells), from which the hairs arise, seen as irregular scattered prominences (*hb*). × 22. V. 22647.

ICACINACEAE

PLATE XVI

Explanation of Plate XVI

FIG. *Stizocarya oviformis* n. sp., p. 340. V. 22659.

1.—A locule-cast with an adherent film of the endocarp, side. × 2.

2.—The same, apex. × 2.

Faboidea crassicutis Bowerbank, p. 341.

3.—An endocarp, base, somewhat worn. × 1·3. V. 22660.

4.—An endocarp with the carpel wall largely preserved, side. × 1·25. V. 22661.

5.—A worn endocarp fractured longitudinally along the funicular canal (*f*), the cast of which (probably broken at the base) is on the right, the placenta (*p*) being at the top. × 1·4. V. 22662.

6.—A locule-cast with remains of the cast of the funicular canal (*f*). The placenta is at (*p*). × 1·7. V. 22663.

7.—Internal cast of a seed showing the groove (*r*) in which the raphe lies. The scar at its upper end is the hilum (*h*). × 1·6. V. 22664.

8.—The same, looking on to the hilum (*h*); the raphe groove (*r*) lies to the right. × 1·6.

9.—Locule-cast (funicle broken) with placenta at the top. × 2·8. Herne Bay. V. 22665.

10.—A much broken locule-cast with remains of the funicle near the top and on the left. × 1·6. V. 22666.

Icacinicarya platycarpa n. gen. & sp., p. 345.

11.—Locule-cast with a film of endocarp adhering. × 1·7. V. 22686.

12.—A broader locule-cast. × 1. V. 22687.

13.—A narrow locule-cast. The testa is visible at (*s*). × 1. V. 22688.

14.—Locule-cast with remains of the endocarp over the centre, showing the sculpture. × 1. V. 22689.

15.—A locule-cast showing the placenta as an apical projection (*p*). × 1. V. 22690.

16.—A locule-cast, broken round the upper margin so as to expose the seed (*s*). × 1·7. V. 22691.

17.—The internal cast of a seed. The left of the two small apical emarginations is the hilum (*h*), from which arise the fibres of the raphe (*r*). × 1·6. V. 22692.

18.—The internal cast of a seed, fractured longitudinally, showing the impression of a cotyledon with puckered edge on its inner surface. The radicle is missing; its position (*r*) is shown by the emargination of the cotyledon. The apparent wall is pyrites filling the interspace left between embryo and testa by decay of the albumen. × 2·5. V. 22693.

Icacinicarya ovoidea n. sp., p. 347.

19.—A locule-cast and seed. The impression of the raphe (*r*) is obscurely seen on the left, near the base, as a dark longitudinal streak. × 2·7. V. 22698.

20.—A locule-cast showing on its surface the digitate cells lining the locule. × 2·7. V. 22699.

21.—The digitate cells of the last specimen. × 13.

Icacinicarya ovalis n. sp., p. 348.

22.—An endocarp, somewhat abraded, side. × 1·8. V. 22702.

FIG.

23.—An endocarp, side, fractured to expose the seed (*s*). × 1·8. V. 22703.

Icacinicarya nodulifera n. sp., p. 349.

24.—An endocarp, fractured longitudinally to expose the loculc-cast. The funicle (*f*) is within the wall on the right, (*p*) marking the placenta. In the middle, where the locule-cast is broken, is the testa (*t*). × 2·7. V. 22706.

25.—A broken endocarp showing, on the left, the nodular exterior. On the right the seed (*s*) is exposed. × 2·7. Herne Bay. V. 22707.

Icacinicarya foveolata n. sp., p. 350.

26.—Fruit, exterior. × 1·7. V. 22710.

27.—The same, side, with approximately half the pericarp removed along the plane of dehiscence. The large secreting cells are elongate over the raphe (*r*). × 2·77.

28.—The same, seen at right angles to the preceding. × 2·77.

Icacinicarya minima n. sp., p. 351.

29.—A worn endocarp, apex, showing the cast of the funicular canal (*f*). × 2·8. V. 22712.

30.—A distorted locule-cast, side, showing, through a break, the seed (*s*) within. × 2·8. V. 22713.

31.—The same, apex, showing the placenta (*p*), and the funicular canal as a groove at the top of the figure. The ridge below marks the junction of the two valves. × 2·8.

32.—A worn endocarp, side. The funicle (mostly broken) is on the right. × 2·8. V. 22714.

33.—The same, looking on to the funicular canal (*f*) and placenta (*p*). The cast of the canal is mostly missing. The apertures to the small canals flanking the placenta can be seen. × 2·8.

34.—The internal cast of a seed. × 2·8. V. 22715.

Icacinicarya Jenkinsi n. sp., p. 352.

35.—A locule-cast. × 2·8. Herne Bay. V. 22720.

36.—The same, reverse. × 2·8.

Icacinicarya bognorensis n. sp., p. 355. V. 22724.

37.—A locule-cast. The placenta is at the top of the figure. × 2·6. Bognor.

38.—The same, apex. The two black dots near the lower rim of the light area are the scars of the placenta (*p*) and style (*st*). × 5.

Icacinicarya sp. 11, p. 355.

39.—An endocarp, side. × 1. V. 22725.

Icacinicarya sp. 12, p. 356.

40.—An endocarp, side. × 2·8. V. 22726.

41.—The same, margin, placenta at the top of the figure. × 2·8.

Icacinaceae ? Genus ?, p. 357.

42.—A locule-cast, carpel wall adhering at the base. × 2·8. V. 22730.

43.—The same, apex. × 1·6.

ICACINACEAE

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PLATE XVII

Explanation of Plate XVII

FIG.

Palaeallophylus ovoideus n. gen. & sp., p. 360.

1.—A seed, showing the large hilar area, with two smaller median scars of the hilum (*h*) and micropyle (*m*). × 3. V. 22731.

2.—Another seed, side, covered by the worn testa. The curve on the left marks the limit of the pocket (*r*) containing the radicle. (The specimen has now perished). × 3.

3.—A longitudinal fracture through a seed, showing the embryo separated from the testa (extreme periphery) by a thick wall of pyrites. The radicle (*r*), surrounded by the worn remains of the pocket of testa (dark), faces the camera. × 3. V. 22732.

4.—A seed-cast, in form resembling the embryo, showing the large radicle (*r*) surrounded by the remains of the pocket (best seen below and on the left). × 3. V. 22733.

5.—A seed-cast showing the radicle (*r*) and impression of the cotyledons (*c*), with remains of the testa between, and the transverse band of the chalaza (*ch*) on the left. × 3. V. 22734.

6.—Another seed-cast, looking on to the chalazal scar (*ch*). × 3. V. 22735.

7.—A seed-cast, side, showing the impressions of the folded cotyledons; both are transversely folded on themselves. × 2·8. V. 22736.

Palaeallophylus rotundatus n. sp., p. 362.

8.—A seed, external surface. × 1·7. V. 22740.

9.—The same, fractured longitudinally, showing the very thick testa with a thin layer of pyrites between it and the internal cast of the seed. The long slender radicle faces the camera. × 3.

10.—The seed-cast from the last, isolated, side. The radicle lies right, and the chalaza (*ch*) left. The division between the cotyledons (c^1, c^2) is a faint curved line rising from the hypocotyl. × 3·1.

11.—The same, opposite side. The folds of the cotyledons show obscurely below the light patch. The radicle (*r*) lies to the left. × 3·1.

12.—The same, looking on to the slender radicle. × 3·1.

Palaealectryon spirale n. gen. & sp., p. 363.

13.—Seed with abraded testa. The radicular pocket (*r*) lies to the right; the hilar area is at the flattened base of the figure. × 2. V. 22741.

FIG.

14.—The same, base, looking on to the hilum. The radicular pocket (*r*) is to the right. × 1·8.

15.—The seed-cast after removal of the testa, showing the radicle (*r*) to the right, and the spirally coiled cotyledons. The long curved line cutting across the cotyledons appears to be associated with the chalaza. × 3·1.

16.—The same, reverse. × 3·1.

17.—The same, looking on to the radicle (*r*). × 3·1.

18.—The same, looking on to the transverse band of the chalaza (*ch*). × 3·1.

19.—A second seed with the worn testa showing fibres. × 1·7. V. 22742.

Cupanoides tumidus Bowerbank, p. 366.

20.—A capsule showing the three valves, apex. × 1·8. V. 22744.

21.—A capsule from which the near valve has been removed, with a locule-cast (*l*) on the right. × 1·8. V. 22745.

22.—A single valve, looking on one of the inner faces. Note the very thick carpel wall (right) and the straight ventral margin (left). Within the broken locule-cast is the seed-cast, the radicle (*r*) being turned towards the exterior of the fruit. × 6·6. V. 22746.

Cupanoides grandis Bowerbank, p. 368.

23.—A small capsule, perhaps abortive, showing a prominent apex. × 2. V. 22752.

24.—The same, base. × 2.

25.—Another small capsule with depressed apex. × 2. V. 22753.

26.—A more developed capsule. × 2. V. 22754.

27.—A four-loculed capsule, apex (abraded). × 1·1. V. 22755.

28.—A well-developed capsule, base. × 2. V. 22756.

29.—A small capsule, apex. V. 22757.

30.—A detached loculicidal valve, inner face. × 2. V. 22758.

31.—A locule-cast, showing impressions of the fibres lining the locule. The longitudinal ridge is the median dorsal line. × 2·1. (Specimen decayed.)

32.—A locule-cast, flattened dorsi-ventrally during fossilization, ventral margin. Note the basi-ventral placenta (*p*). × 2·1. (Specimen decayed.)

33.—A locule-cast, fractured longitudinally to show the seed within. Note the radicle (*r*) turned towards the exterior of the fruit. × 2·7. V. 22759.

Photo M.E.J.C.

SAPINDACEAE

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PLATE XVIII

Explanation of Plate XVIII

Sapindospermum ovoideum n. gen. & sp., p. 371. V. 22768.

FIG.

1.—A seed, looking on to the hilum. The radicle lies towards the bottom of the figure. × 2·75. Herne Bay.

2.—The same, looking at the radicle (*r*) partly hidden by the adhering testa below; the testa has come away above, exposing the seed-cast. × 3.

3.—The same, side, with the division between the cotyledons (*c*, *c*) showing as a thin transverse line. The radicle is at (*r*), the testa at (*t*). × 3.

4.—The same, with the radicle (*r*) turned more towards the observer. The junction of the cotyledons (*c*, *c*) is a thin line on the right. The deep groove at the proximal end of the radicle is seen also in figs. 2, 3. × 3.

5.—The same, reverse of fig. 2, showing the margin of the outer cotyledon, where it rests on the inner cotyledon, as a curved transverse line. × 1·6.

Sapindospermum Jenkinsi n. sp., p. 371. V. 22769.

6.—Seed-cast with slight remains of the testa (on the left), looking on to the radicle (*r*). Note the transverse furrow at the proximal end of the radicle. × 2·6. Herne Bay.

7.—The same, reverse, showing the margin of the outer cotyledon, c_1 (upper curved line; the lower line is an accidental break), resting on the inner cotyledon, c_2. × 2·6.

8.—The same, side, with the radicle (*r*) facing left. The cotyledons, c_1 and c_2, are separated by a curved transverse line. × 2·6.

Sapindospermum grande n. sp., p. 372. V. 22770.

9.—A seed with remains of the testa. The hilum (*h*) is below, the radicle (*r*) is to the left. × 1·4.

10.—The same seed, showing a circular scar at the end opposite to the hilum. × 1·4.

11.—The same, with the testa removed, except a closely adhering film; looking on to the radicle (*r*). × 2·9.

Sapindospermum sp. 4, p. 373. V. 22771.

12.—Seed-cast with remains of testa at the base; the radicle is towards the left, the curved cotyledons are obscure. × 2·7.

13.—The same, reverse. × 2·7.

14.—The same, looking on to the radicle. × 2·8.

Sapindaceae, Genus ?, p. 374. V. 22772.

15.—A locule-cast, with remains of the axis to the left. × 1·6.

Meliosma Jenkinsi n. sp., p. 375.

16.—Locule-cast, side, with the attachment on the left. × 3·1. V. 22773.

17.—The same, ventral. The apparent large scar approximating in outline to the endocarp is an accidental fracture. The true plug (*p*) is the oval area within this, delimited by a ridge on the right and a groove on the left. Around the plug the endocarp itself is preserved. × 3.

18.—The same, dorsal, showing the median keel. × 2.

FIG.

19.—The same view as in figs. 17 and 21. The plug of endocarp seen in fig. 17 is removed, and with it the left ventral margin of the cup-shaped locule-cast (cf. figs. 30, 33); below, and on the lower right, the whole of the locule-cast is removed exposing the seed (*s*); in the centre is the horseshoe-shaped ventral face of the locule-cast (really sub-circular, but interrupted at the base by pyrites) with the funicular canal (*f*) at its centre. × 3.

20.—The counterpart of fig. 19 showing the interior of the fractured portion. × 3.

21.—The same view as fig. 19. showing the seed-cast after the remains of the locule-cast and thick testa have been removed so as to expose its ventral surface. At the centre is the chalaza (*ch*). × 3.

22.—A second specimen, fractured dorsi-ventrally approximately along the line of the dorsal ridge. The endocarp is preserved, and the white mass within is the locule-cast. The collapsed seed (*s*) is a grey sinuous line. The dark central mass is the wall of the testa, much thickened around the hilum. × 2. V. 22774.

23.—A much worn endocarp, ventral. The large spathulate plug lies in the middle, and around it much of the carpel is preserved. × 3·3. V. 22775.

Meliosma cantiensis n. sp., p. 376.

24.—An endocarp, ventral. × 3. V. 22778.

25.—The same, side. × 3.

26.—A locule-cast, ventral; the plug of tissue which is associated with the funicle remains in the hollow. × 3. V. 22779.

27.—The same, dorsal. × 3.

28.—A locule-cast with remains of the endocarp below, dorsal. The surface shows the long digitate cells which line the endocarps of *Meliosma*. × 6. V. 22780.

29.—Endocarp, side, with seed exposed by removal of the locule-cast. The ventral side is to the right, the dorsal to the left. × 6. V. 22781.

30.—The same, dorsi-ventral section approximately along the dorsal ridge, showing the plug (*p*) of loose tissue at the attachment; the incurved walls of the endocarp are preserved within the ventral hollow. The seed-cavity (*s*) is seen in section filled with white pyrites. × 6.

Meliosma sheppeyensis n. sp., p. 378.

31.—An endocarp much abraded, side. × 3. V. 22785.

32.—The same, ventral. × 3.

33.—Much worn endocarp, fractured dorsi-ventrally along the median ridge, showing the incurved ventral wall (*vw*). × 6·5. V. 22786.

Vitis subglobosa n. sp., p. 379.

34.—A seed, dorsal, with large chalaza. The testa is broken on the right. × 5·6. V. 22788.

35.—The same, ventral, showing the rounded median ridge flanked by the short infolds. × 5·6.

36.—Internal cast of a seed, dorsal. × 6·5. Herne Bay. V. 22789.

37.—The same, ventral. × 6·5.

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SAPINDACEAE, SABIACEAE, VITACEAE

PLATE XIX

Explanation of Plate XIX

FIG. *Vitis semenlabruscoides* n. sp., p. 380. V. 22790.

1.—Two seeds, dorsal. The chalaza of the left specimen is seen in surface view, that of the right, in profile on its right margin. × 5·6.

2.—The same, ventral. One ventral infold of the right-hand seed is visible, the other infold, and those on the left-hand seed, are obscured by pyrites. × 5·6.

Vitis minuta n. sp., p. 381. V. 22791.

3.—Seed, dorsal, showing the large chalaza. × 6·5. Assington, Suffolk.

4.—The same, ventral. The infolds are filled with the matrix. × 6·5.

Vitis bognorensis n. sp., p. 382. V. 22792.

5.—A seed, dorsal; internal cast. The black carbonaceous testa remains over the long oval chalaza. Note the apical groove for the passage of the raphe. × 6·5. Bognor.

Tetrastigma globosa n. sp., p. 383.

6.—Seed-cast (distorted), dorsal, showing the impression of the internal chalaza. × 6·6. V. 22794.

7.—The same, ventral, with remains of the testa along the margins of the two infolds, which are otherwise obscured by pyrites. × 6·6.

8.—The internal cast of an undistorted seed, ventral. × 6·7. V. 22795.

Tetrastigma ? longisulcata n. sp., p. 384. V. 22797.

9.—Internal cast of seed, dorsal, showing the impression of the internal chalaza. × 5·8.

10.—The same, ventral, showing the two long infolds. × 5·8.

Ampelopsis crenulata n. sp., p. 385. V. 22798.

11.—Internal cast of seed, dorsal, showing the chalaza. × 6·7.

12.—The same, ventral. Some of the testa remains around the ventral depressions. × 6·7.

Ampelopsis rotundata n. sp., p. 386.

13.—A seed, dorsal, showing the large chalaza. × 6·7. V. 22800.

14.—The same, tilted to show the gradual widening of the thick raphe into the chalaza at the apex. × 6·7.

15.—The same, ventral, showing the infolds rather obscurely. × 6·7.

16.—Internal cast of a seed, ventral, showing the infolds clearly. × 6·7. V. 22801.

17.—The same, dorsal, showing the internal chalaza. × 6·7.

FIG. *Cayratia ? monasteriensis* n. sp., p. 387. V. 22802.

18.—Internal cast of a seed with remains of the testa, dorsal, showing the chalaza. × 6·7.

19.—The same, ventral, showing the long infolds. × 6·7.

Palaeovitis paradoxa n. gen. & sp., p. 388.

20.—A seed, dorsal. The testa is largely abraded over the chalaza. × 2·8. V. 22804.

21.—The same, ventral, showing the short infolds. × 2·8.

22.—A perfect seed, dorsal, showing the chalaza. × 6·6. V. 22805.

23.—The same, in asymmetric longitudinal section, showing the thick testa. The chalaza (*ch*) is a plug-like segment of the wall near the left base. The section passes through the cavity of the seed (*cav*) and one of the deep ventral infolds (*in*), on the right, the white mass filling it being pyrites. Between the seed-cavity and the base of the infold the testa is very thin. × 6·6.

24.—A seed-cast from which the testa is abraded except in the ventral infolds, where it remains around the pyrites filling their hollows, ventral. × 6. V. 22806.

25.—The same, dorsal, showing the large internal scar of the chalaza. × 6.

26.—The same, lateral margin. × 5·8.

27.—Seed, apical margin, with much of the very thick testa preserved. The chalaza (not seen) is turned upwards, at right angles to the plane of the figure. The ventral infolds (*in*), foreshortened, are on the lower margin. Where the seed-cast is exposed the wide groove for the raphe is seen above its margin, and the median ventral ridge below. × 6·6. V. 22807.

Echinocarpus priscus n. sp., p. 390.

28.—A fruit, side; carpel abraded, except at the top and bottom, and locule-casts exposed. × 1. V. 22809.

29.—The same, base, showing axis of the fruit. The left locule-cast is broken. × 1.

30.—The same, side, after fracture of two of the locule-casts. × 1·5.

31.—Fruit, with the pericarp preserved (note radially directed fibres), sectioned longitudinally, with two locules and the thick fibrous axis between. × 1·3. V. 22810.

32.—The same, exterior. × 1·3.

33.—Fruit, broken to show the seeds. One septum (partly pyritized) is displaced and sinuous owing to unequal development of the seeds. Two seeds (dark, slightly broken) lie embedded in the left locule cast (white); and the remains of one in the right. The chalaza in every case lies towards the exterior of the fruit. × 3. V. 22811.

34.—A seed, isolated, side. The chalaza is at the broad end. × 3. V. 22812.

35.—A seed, looking on to the chalaza (round black scar). × 3. V. 22811.

Brit. Mus. (Nat. Hist.) LONDON CLAY FLORA Plate 19.

Photo M.E.J.C.

VITACEAE, ELAEOCARPACEAE

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PLATE XX

Explanation of Plate XX

FIG. *Echinocarpus sheppeyensis* n. sp., p. 392. V. 22814.

1.—A fractured fruit, exterior, with part of the pericarp removed from the right segment to show the locule-cast. × 1·5.

2.—The same, segment showing the axis, an abortive locule (left), and a fertile locule (right). Within the latter, on the hollow locule-cast, is a seed impression. × 1·6.

3.—The counterpart of the right-hand portion of fig. 2, showing the seed-cast, with some of the testa preserved. The chalaza (*ch*) appears as a swollen scar. × 1·6.

Cantitilia polysperma n. gen. & sp., p. 393.

4.—A fruit, fractured longitudinally, with ripe seeds (left) showing the displaced axis (*a*). × 5·9. V. 22815.

5.—A somewhat worn fruit, exterior, with the fibrous layer exposed. × 1·8. V. 22816.

6.—Another fruit, tilted to show the base. × 1·8. V. 22817.

7.—A small fruit, side, with some of the exocarp preserved, concealing the fibrous layer. × 1·8. V. 22818.

8.—An abortive fruit fractured longitudinally. The locules contain abortive seeds; the thick axis widens below. × 3. V. 22819.

9.—A fruit fractured transversely near one end. The irregular arrangement of the remains of three seeds (*s*) is due to the displacement or rupture of the thin septa. The globular secreting cells of the testa can be seen in section. At the periphery of the fruit is the fibrous layer in section and, within this (whitish), the thick spongy coat of the pericarp. × 6·5. V. 22820.

10.—A transverse fracture across an abortive fruit. The placentation of the abortive seeds (black) in the three upper locules is axile; the two lower ones are occupied by galls (*g*). × 6·5. V. 22821.

11.—A seed with a portion of the carpel adhering on the right. The chalaza (*ch*) shows as a black scar. × 6·6. V. 22822.

Sphinxia ovalis n. gen. & sp., p. 397.

12.—A fruit, broken longitudinally before photography, exterior of larger fragment. × 2. V. 22838.

13.—Exterior of smaller fragment. × 2.

14.—The two fragments in place, apex. × 2.

15.—The same, base. × 2.

16.—The smaller fragment, interior, showing seeds, and axis. × 2·8.

FIG.

17.—The larger fragment, interior (counterpart of last). × 2·8.

18.—The chalaza of a seed showing through the worn carpel wall. × 8. V. 22838.

19.—Separate locule-casts from another fruit, placed together for photography, apex. × 1·5. V. 22839.

20.—One of the locule-casts from V. 22839, dorsal, partly dissected to expose the seeds within. The chalazal scars have broken away. × 1·5.

21.—A seed lying in a locule-cast. The strand of fibres is part of the axis. Note the fringe of radiating hairs around the seed. × 6. V. 22839.

22.—One of the valves of the pericarp, interior. The ridge is part of the septum. × 3. V. 22839.

23.—Dorsal surface of a locule-cast showing impressions of the long hairs surrounding the chalazal end of the seeds (*s*) which lie within the cast on each side of the median ridge. × 6. V. 22839.

Tetracera eocenica n. sp., p. 400.

24.—A seed-cast with most of the testa abraded, base. Note the prominence associated with the radicle (*r*). The chalaza (*ch*) is circular at the base of the figure. × 6·7. V. 22842.

25.—The same, side; (*r*) is the radicle. × 6·7.

26.—A seed with much of the testa preserved, base; (*h*) is the hilum. × 2·8. V. 22843.

27.—The same, side. × 2·8.

28.—The same, fractured longitudinally through the hilum (*h*) and chalaza showing the testa in section, and the seed-cast with the prominence of the radicle (*r*) lying within. × 2·8.

29.—Seed-cast with remains of testa. The radicle is at the top. The large-celled layer of the testa is exposed immediately above the white edge of pyrites. × 6·5. V. 22844.

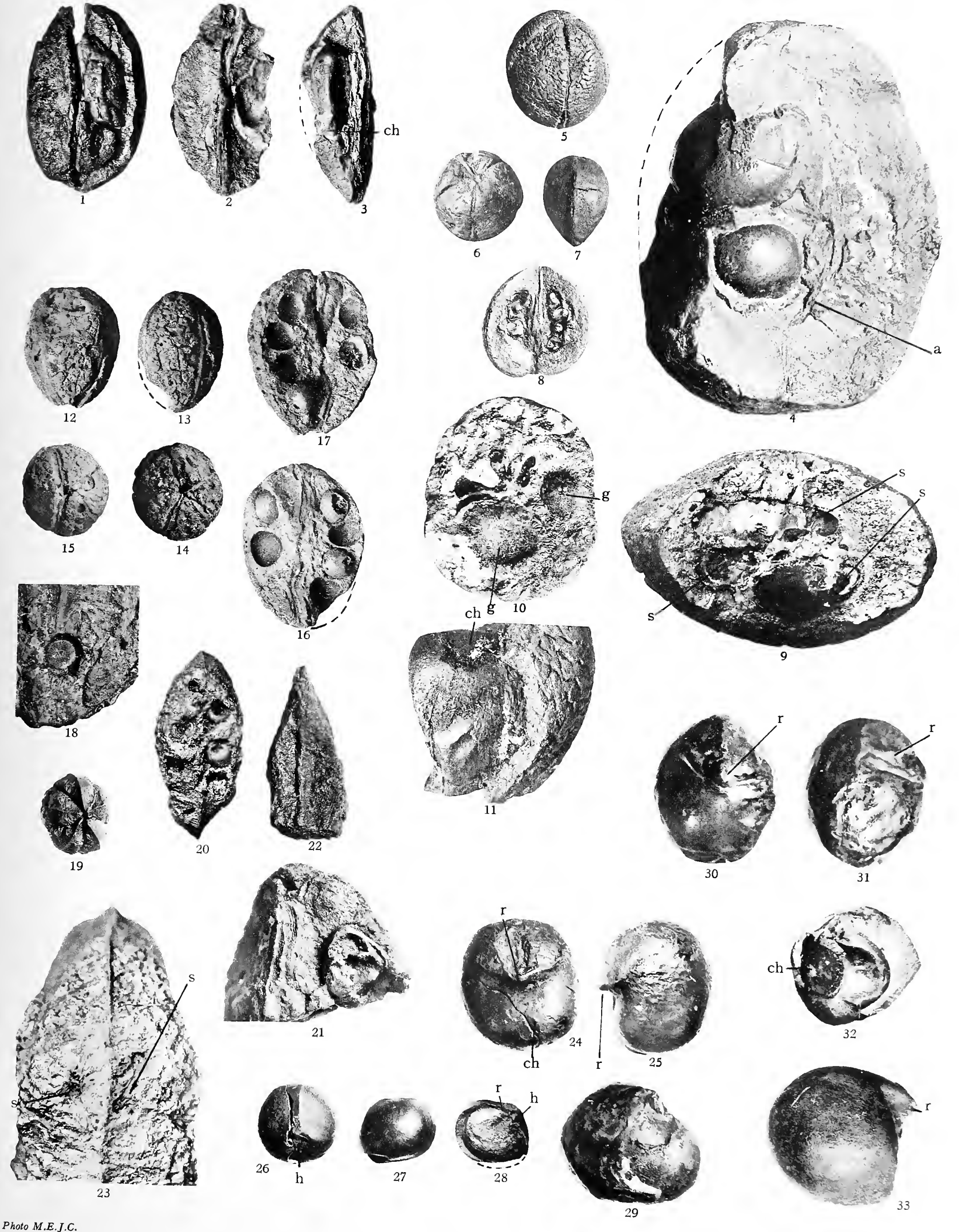
Tetracera ? cantiensis n. sp., p. 402.

30.—A seed with remains of testa, base. The radicle (*r*) faces the camera. × 6·5. V. 22850.

31.—The same, side; (*r*) is the radicle. × 6·5.

32.—Seed fractured to show the chalaza (*ch*). It probably belongs to this species. × 6·5. V. 22851.

33.—A seed, exterior, which may also belong to the same. The radicle (*r*) faces right. × 6·5. V. 22852.



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ELAEOCARPACEAE to DILLENIACEAE

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PLATE XXI

Explanation of Plate XXI

FIG.

Tetracera ? sheppeyensis n. sp., p. 403.

1.—A seed with the testa preserved, base. × 2·8. V. 22854.

2.—The same, side. The radicle (*r*) faces left. × 2·8.

3.—The same, ventral, with part of the testa removed, showing the round chalazal scar (*ch*). The radicle points upwards. × 6·5.

4.—The same, also ventral, but tilted forwards the better to show the chalaza (*ch*). × 6·5.

Ternstroemiaceae ? Genus ?, p. 404. V. 22855.

5.—A fruit, somewhat broken and worn. The longitudinal ridge is a locule-cast protruding through the carpel wall. × 2·7.

6.—The same, base. × 2·7.

7.—The same, with an oblique segment taken off near the apex so as to expose three of the locule-casts. × 2·7.

8.—The same, fractured longitudinally, showing the axis, the parenchyma, and the radially aligned cells of the peripheral layer of the pericarp. × 6·5.

Oncoba variabilis (Bowerbank), p. 406.

9.—A broken fruit with part of the pericarp preserved. × 1·4. V. 22857.

10.—A placental mass with embedded seeds (*s*), probably the base. × 1·4. V. 22858.

11.—Another placental mass, probably the apex. × 1·4. V. 22859.

12.—Placental mass partly covered by the pericarp. × 1·1. V. 22860.

13.—An abnormally small placental mass. × 1·1. V. 22861.

14.—A segment of a placental mass, to show the way in which the seeds are embedded. × 2·8. V. 22862.

15.—Part of a placental mass, to show the large pulp (?) cells, and fibres probably associated with placentation. × 9. V. 22863.

16.—Part of a placental mass, to show the large tortuous cells in contact with the pockets in which the seeds lie, also, on the film of pyrites lining these, impressions of the testa cells. × 8·6. (Specimen now disintegrated.)

17.—A seed-cast with remains of the testa. The mucro (*m*) at the top of the figure is the cast of the micropyle. × 8·5. V. 22864.

FIG.

18.—A seed, to show the circular scar of the chalaza (*ch*). × 8·5. V. 22865.

Oncobella polysperma n. gen. & sp., p. 412.

19.—A worn fruit, exterior with seed-casts exposed. × 1·9. V. 22872.

20.—The same, base. × 1·9.

21.—The same, fractured longitudinally, showing the irregular arrangement of the seeds. × 5·6.

22.—The same, exterior, showing the arrangement of the seeds. The regular peripheral groove delimiting the group of seeds perhaps indicates a fallen valve. × 5·6.

23.—A seed-cast, side. The small mucro at the apex of the figure is the cast of the micropyle. × 8. V. 22872*a*.

24.—Another seed, inverted to show the small round chalaza (*ch*). × 8. V. 22872*b*.

Haloragicarya quadrilocularis n. gen. & sp., p. 413.

25.—A fruit, side, with locule-casts showing below. × 6·5. V. 22873.

Minsterocarpum alatum n. gen. & sp., p. 416.

26.—A fruit, slightly worn. × 2. V. 22874.

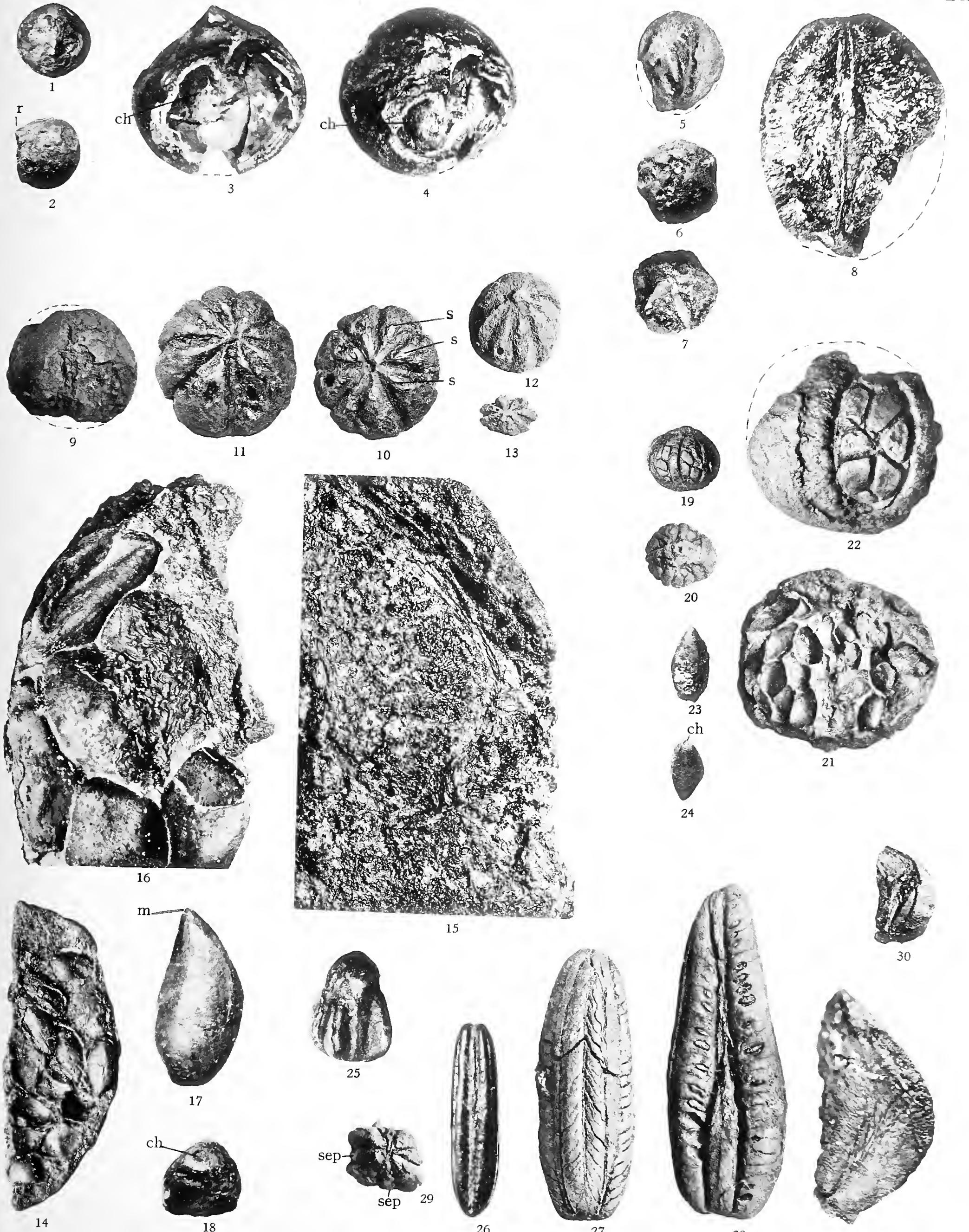
27.—A more worn fruit, with the seeds (wings) showing. Between the rows of seeds the carpel remains. The fruit is breaking along the surfaces of the seeds. × 3·1. V. 22875.

28.—Another worn fruit, showing seeds. Between the two developed locules lies, near the base, a small, less developed one. In some cases the wings of the seeds have been worn, exposing the seed-body within. × 3·1. V. 22876.

29.—The apex of a four-loculed fruit, showing locule-casts with septa (*sep*) between. × 3·1. V. 22877.

30.—A seed from V. 22875, upper surface. The testa has come away over the body of the seed, but not over the wing. × 6·5.

31.—A seed from the same fruit, lower surface. × 13.



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DILLENIACEAE to LYTHRACEAE

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PLATE XXII

Explanation of Plate XXII

Pachyspermum quinqueloculare n. gen. & sp., p. 419. V. 22880.

FIG.

1.—A worn fruit (broken at the apex) with the seeds partly exposed. × 1·8.

2.—The same, transversely fractured, showing the seeds attached to radial axile placentas. × 5.

3.—The same, part of the surface to show the worn apex of the seeds. In the middle seed the appendage of the raphe (*a*), as seen in section, is triangular; the seed-body (white) is below it; the chalaza (*ch*) lies at the junction of the seed-body and wing. × 19.

4.—Part of the same, fractured longitudinally, showing the seeds lying one above the other. The axis lies to the left of the figure. The top seed, left, is perfect, the wing (*w*) lies uppermost and the body (*b*) is below. Second from the bottom is the impression of the external surface of a seed (*es*), (*b*) is the body of another seed. × 19.

5.—A portion of the exterior surface, to show the septum, exposed through abrasion. The locule-lining is almost entirely worn away, only small patches of transverse cells being preserved near the septum. The mass of seeds is embedded in pyrites. × 9.

6.—A seed, perfect, except that the epidermis is worn away. The seed-body lies to the left, the raphe and its appendage to the right. × 19.

7.—A seed-cast with the testa and raphe appendage removed in order to show the chalaza (*ch*). The seed has the same position as in fig. 6. × 19.

Tamesicarpum polyspermum n. gen. & sp., p. 421.

8.—A fruit, pericarp abraded and some seeds exposed, exterior. The testa also is worn from the exposed dorsal surfaces of the seeds, but is seen in section around the seed-casts. × 6. V. 22881.

9.—The same, viewed more from the left and with some of the front face removed. The seeds s_1, s_2, are those similarly labelled in fig. 8. On the right the axile placentation of the seeds can be traced. × 6·6.

10.—A fruit from which most of the pericarp is abraded, but the peduncle is preserved. × 3. V. 22882.

11.—A three-loculed fruit, tilted to show the apex; the locule-casts, in part covered by the pericarp, bear impressions of the transverse fibres lining the locule. The median longitudinal ridges of pyrites on the surface of the casts, which rise from the apex (best seen on the right-hand and top locules), indicate loculicidal dehiscence, pyrites having filled the cracks between the now largely abraded valves. × 3. V. 22883.

FIG.

12.—A fruit showing locule-casts, and some of the pericarp at the base. On the surfaces of the casts are the impressions of seeds obliquely superposed. One of the septa lay in the deep groove (*sp*). × 2·1. V. 22884.

13.—A fruit represented by two locule-casts only; that on the right shows a double row of seeds, with a depression between, marking the median plane of the locule. The deep groove (*sp*) between the locules marks the septum. × 2·1. V. 22885.

14.—A fruit, tilted to show the base, with four locule-casts adhering to the thick axis. × 2·1. V. 22886.

15.—The same, apex. × 2·1.

16.—A five-loculed fruit, base. × 2. V. 22887.

17.—A fruit, of which only two locule-casts remain, showing particularly well the arrangement of the seeds. Quadrangular impressions are seen on the left, and simple oblique impressions on the right. × 2·1. V. 22888.

18.—A seed-cast. The ventral angle (between the dark and light surfaces) faces the camera. × 7·5. V. 22881.

19.—Another seed-cast, ventral, with no ventral angle. × 13·5. V. 22881.

20.—A broken seed with remains of testa, showing the large cells. The ventral angle is to the right; part of the dorsal surface (not seen in figs. 18, 19) is on the left. × 8·1. V. 22881.

21.—A portion of V. 22881, showing a seed in section. Note the large testa cells (dark). × 6.

Cranmeria trilocularis n. gen. & sp., p. 424.

22.—A fruit, exterior. × 1·8. V. 22893.

23.—A fruit, fractured longitudinally, to show the locules filled with seeds. × 3·1. V. 22894.

24.—The same, transverse section of part of a locule, showing many rows of seeds diverging from the placenta. × 9.

25.—The same, a portion of one of the locules to show the obliquely superposed seeds. The testa is seen on the uppermost seed, and a seed-cast (white) below it. × 18.

26.—V. 22893, after an oblique segment had been cut from the apex, but before the fracture seen in fig. 22. It shows (left) beneath the pericarp the exterior of a locule-cast (*l*), and (right and middle) a sectioned locule with seeds (*s*). × 2·8.

27.—Counterpart of the blocked area seen in fig. 26, to show the seed. × 19.

28.—Internal cast of a seed showing impressions of the testa cells. The chalaza (*ch*) is at the top of the figure. × 19. V. 22894.

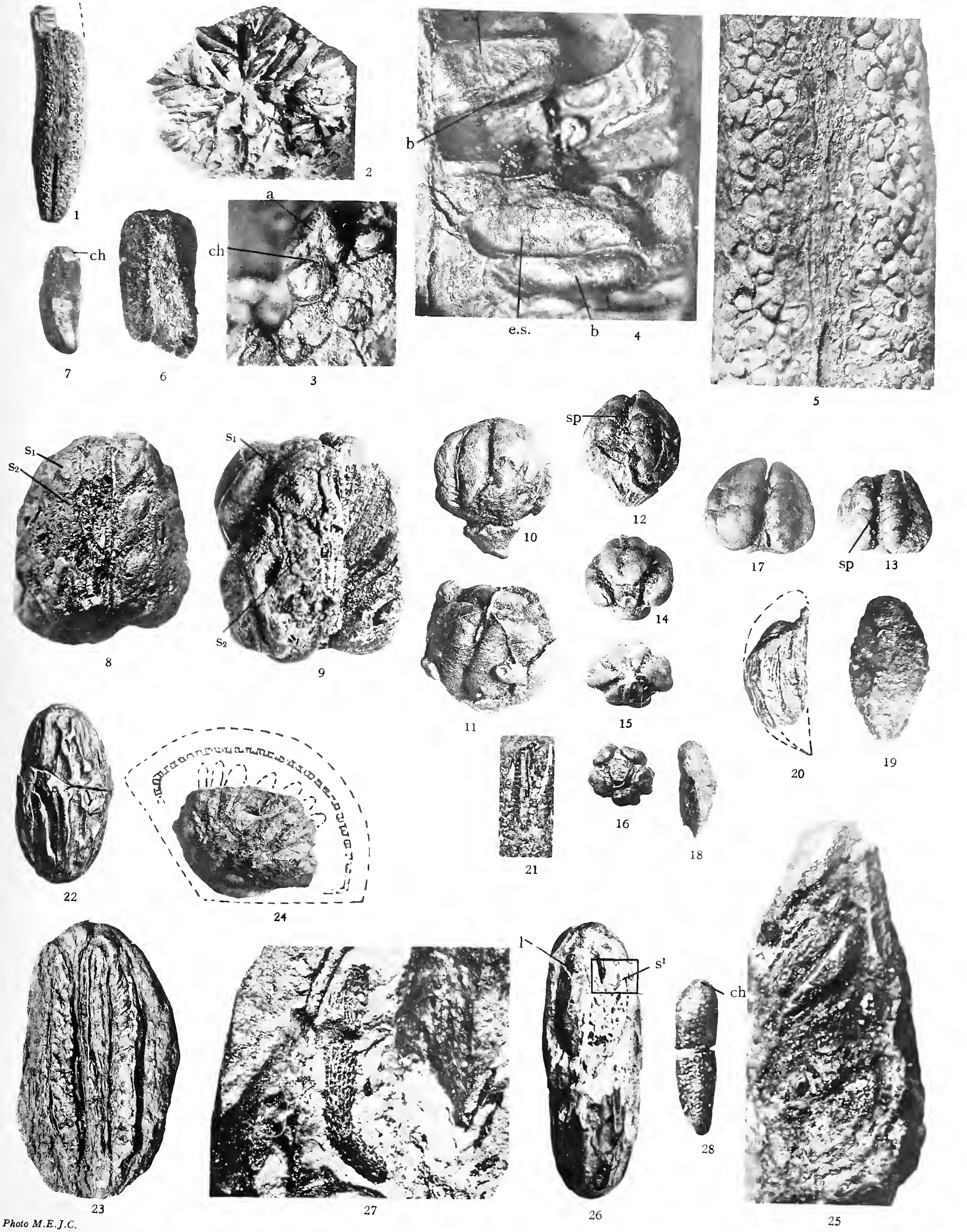

Photo M.E.J.C.

LYTHRACEAE

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PLATE XXIII

Explanation of Plate XXIII

Palaeeucharidium cellulare n. gen. & sp., p. 426. V. 22895.

FIG.

1.—A fruit, pericarp abraded. The body of a large seed faces the camera, and is surrounded by a large wing (not very clearly seen). The central groove carries the raphe. × 6·7.

2.—The same, another aspect, showing two seeds (right and left) more in profile. That on the right is seen in fig. 1. Very large long cells surround the seed-body, and form wing-like appendages turned towards the axis of the fruit. × 6·6.

3.—The fruit tilted to show the apex of the right-hand seed in fig. 2, with the median furrow across the wing. × 6·6.

4.—The fruit in longitudinal section showing the axis and septa. × 6·6.

Protonyssa bilocularis n. gen. & sp., p. 429.

5.—An endocarp, exterior, showing the pyritized longitudinal bands of fibres. The germination valve (*v*), on the left, is indicated by the curve in the upper part of one of the bands of fibres. × 2·1. V. 22896.

6.—An irregular longitudinal fracture through the same, showing the ventral face of a seed-cast half covered, to the left of the longitudinal ridge (*r*) above the raphe, by the overlying ventral wall of a nearer carpel, the rest of which, with the contained seed, has been removed. × 2·1.

7.—The same, in approximately the same position as in fig. 5 after the valve has been removed; a little of the outer surface of the endocarp has also come away. Beneath the valve is seen the hilar end of the seed. × 1·83.

8.—A much abraded endocarp, showing the two locule-casts in position. × 1·8. V. 22897.

9.—The seed, ventral, removed from V. 22896, seen in approximately the same position as in fig. 6. The median raphe shows clearly below. × 1·8.

10.—The same, dorsal. The median rib is an adhering fibre from the locule.

Palaeonyssa multilocularis n. gen. & sp., p. 431.

11.—An endocarp, exterior, showing (right) a germination valve; worn at the base so that the locule-cast protrudes. × 1·5. V. 22899.

12.—The same, apex, showing the germination valves (*v*) of the three locules. × 1·6.

13.—The same, in irregular longitudinal fracture. On the left is an empty locule, on the right a locule-cast containing a seed (seen in profile). × 1·9.

14.—The counterpart showing (left) the empty locule, and (right) the seed lying in the second locule. × 2·8.

15.—A perfect endocarp. The outline of the germination valve (*v*) is seen as an obscure curved line. × 2·8. V. 22900.

Palaeonyssa sp., p. 433.

16.—An endocarp, exterior. × 1·8. V. 22903.

FIG.

17.—The same, looking on to the irregular transverse fracture seen in fig. 16. × 1·8.

Nyssaceae ? Genus ? sp. 1, p. 434. V. 22904.

18.—A two-loculed endocarp, much abraded; the locule-casts are exposed, and one faces the camera. The left ridge marks its left margin, the right ridge is median, the right margin being hidden in shadow. × 2·7.

19.—The same, in transverse section, showingthe two locule-casts. × 2·8.

Nyssaceae ? Genus ? sp. 2, p. 435.

20.—The internal cast of a seed. × 2·8. V. 22905.

Palaeorhodomyrtus subangulata (Bowerbank) n. gen., p. 436.

21.—A broken fruit, exterior, from which the persistent perianth is worn away. On the left, where the pericarp is completely abraded, the curved internal casts of two seeds are surrounded by the large cells of the testa. × 2·8. V. 22906.

22.—The same, base, showing three carpels. On the left a septum and several seeds (casts and sectioned testa) can be seen. × 2·8.

23.—The same, looking on to the broken side (reverse of fig. 21). A seed-cast protrudes on the right of the axis, and on the left, at the base, is the impression of a seed (*s*) on a pyrites film which lay between the seed and the septum. × 2·8.

24.—Another fruit, side, much abraded, showing dehiscence. × 1·6. V. 22908.

25.—The same, apex; loculicidal dehiscence is shown by the septa (obscure narrow lines near the right and left valves) passing from the apices of the valves to the axis. × 1·6.

26.—A fruit, with persistent perianth and peduncle, which has begun to split. × 1·6. V. 22907.

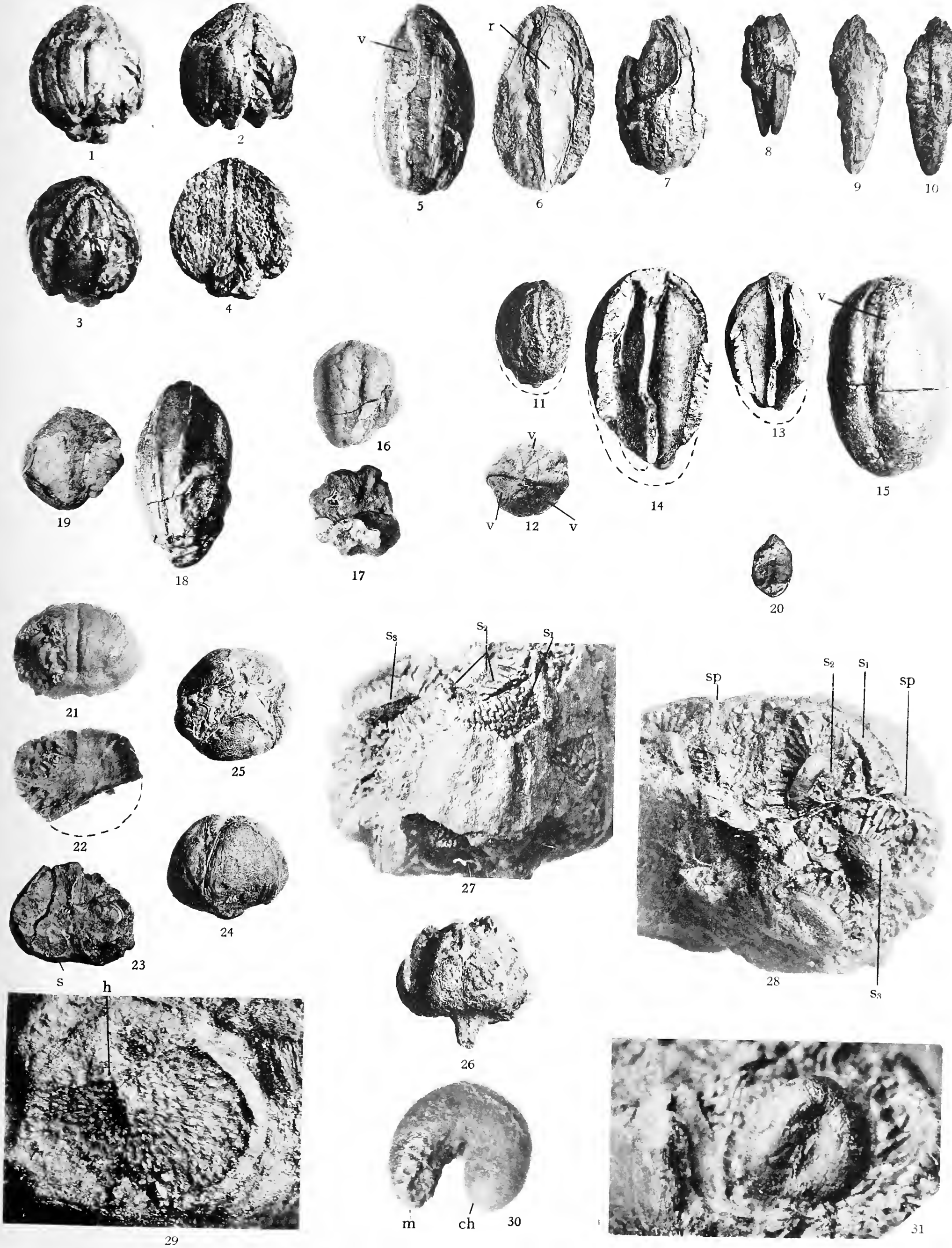
27.—A piece of V. 22906, seen from the exterior, with several seeds (*s*); on s_1 the external surfaces of the large inflated cells of the testa are seen; s_2, s_3, show the testa in section. × 9.

28.—The same fragment showing the broken fruit in irregular transverse section. Septa are seen at *sp*. The seeds marked s_1, s_2 s_3, correspond with those in fig. 27. Note the radial alignment of the large cells of the testa. × 9.

29.—The external impression of the side of a seed (*s* in fig. 23). Note the relative smallness of the superficial layer of cells covering the large cells of the testa. The approximate position of the hilum is indicated by (*h*). × 19.

30.—An isolated seed-cast from V. 22906, showing the transversely aligned cells of the tegmen. The micropyle is at (*m*), the chalaza at (*ch*). × 19.

31.—Part of the same fruit, figured to show a seed-cast (s_2 of fig. 28) from which most of the testa has been removed; the tegmen cells are seen; some of the large cells of the testa still lie around the cast. The testa fills the space between the two limbs of the seed. To the left of the figure is part of the fibrous axis of the fruit. × 19.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h
26
29
m
ch
30
31

PLATE XXIV

Explanation of Plate XXIV

FIG. *Hightea elliptica* Bowerbank, p. 440.

1.—A fruit with pericarp preserved. The epicarp (*e*) is seen only on the dark patch to the right. × 2·8. V. 22911.

2.—Another fruit. The longitudinal fibres are seen obscurely. × 1·3. V. 22912.

3.—A fruit without peduncle. × 1·3. V. 22913.

4.—A fruit, apex. Three valves can be seen near the base of the figure, but the other two have broken away leaving the columella (*c*) exposed. × 1·2. V. 22914.

5.—An unequally five-partite columella, apex. At the apex of each lobe is a hole for the egress of a bundle of fibres which arises from the axis (cf. fig. 9). × 2·8. V. 22915.

6.—A five-partite columella, apex, with remains of the carpel adhering. The star-like ridges are the remains of strands of fibres belonging to coat 3 of the carpel. After passing downwards through the apical cap (here removed) as a single strand (cf. fig. 8) they radiate from the centre to the margin. Here they break up to form the tangled masses of the carpel wall. × 2·5. V. 22916.

7.—A fruit, sectioned longitudinally. It shows in parts the central fibres of the columella (of which the parenchyma is replaced by pyrites), also a pendulous seed in section (right) in the lower part of the locule. × 1·8. V. 22917.

8.—A fruit, fractured longitudinally, showing (below) the space occupied by the stalk of the columella (now broken) and (above) the parenchyma of the columella (*c*). The longitudinal strand of fibres (*f*) passes through the cap (cf. description of fig. 6); and (lower left-hand) a broken seed-pocket shows a seed impression (*s*). The locule-lining is best seen at (*l*) on the dehisced surfaces of the valves. × 5·6. V. 22918.

9.—A longitudinal fracture through an isolated columella. A strand of fibres is given off to a placenta (*p*), and another strand passes to one of the apical apertures (*a*) (cf. fig. 5). × 3. V. 22919.

10.—A worn fruit; the placental angle protrudes as a white cordiform body (lower white mass), the two cusps being the placentas. From the left-hand placenta a funicle passes to the worn and broken erect seed. × 2·8. V. 22920.

11.—The same, placental region, showing placenta (*p*), seed (*s*), and funicle (*f*). × 9.

FIG.

12.—The same, showing two erect seeds at one placental angle (seen on the right margin in fig. 10). × 2·8.

13.—An isolated seed with the testa somewhat worn. The dorsilateral raphe is a longitudinal band of fibres (*r*) on the right. The chalaza is at the base of the figure. × 9·2. V. 22921.

14.—A seed, side. The dorsal surface is on the left. × 4. V. 22922.

15.—A seed, ventral. The flange (*h*) on the left marks the hilum and the beginning of the raphe. × 4. V. 22923.

16.—A seed, dorsal, showing the flattened and flanged hilar end. × 4. V. 22924.

17.—The testa of a seed from V. 22916 (fig. 6). × 16.

Hightea turgida Bowerbank, p. 446.

18.—A fruit, somewhat worn, from which two pendulous seeds have fallen. A placental angle of the columella protrudes through the abraded wall on the left at (*p*). × 1·1. V. 22940.

19.—A fruit, showing the tendency to split into valves. × 1·1. V. 22941.

20.—A fruit, base. The aperture is left by the stalk which has fallen away. × 1·1. V. 22942.

21.—A fruit, apex. The fibrous apical cap is worn away, so that some of the seeds are exposed. × 1·1. V. 22943.

22.—A worn fruit showing a placental angle (*p*) of the columella protruding with two pendulous seeds attached. × 1·1. V. 22944.

23.—A fruit with part of the carpel removed to expose the columella. × 1·1. V. 22945.

24.—An isolated columella. × 1·1. V. 22946.

25.—A columella, apex. Note the grooves in which the strands of fibres lay (cf. fig. 6), and the pairs of placentas at each angle. × 1·2. V. 22947.

26.—A worn fruit, showing a placental angle (*p*) and a pair of seeds, one erect, the other pendulous, arising from it. The two funicles (*f*) pass into the raphe along the left margin of the lower seed, and along the right margin of the upper seed. × 2·8. V. 22948.

Brit. Mus. (Nat. Hist.)

LONDON CLAY FLORA

Plate 24.

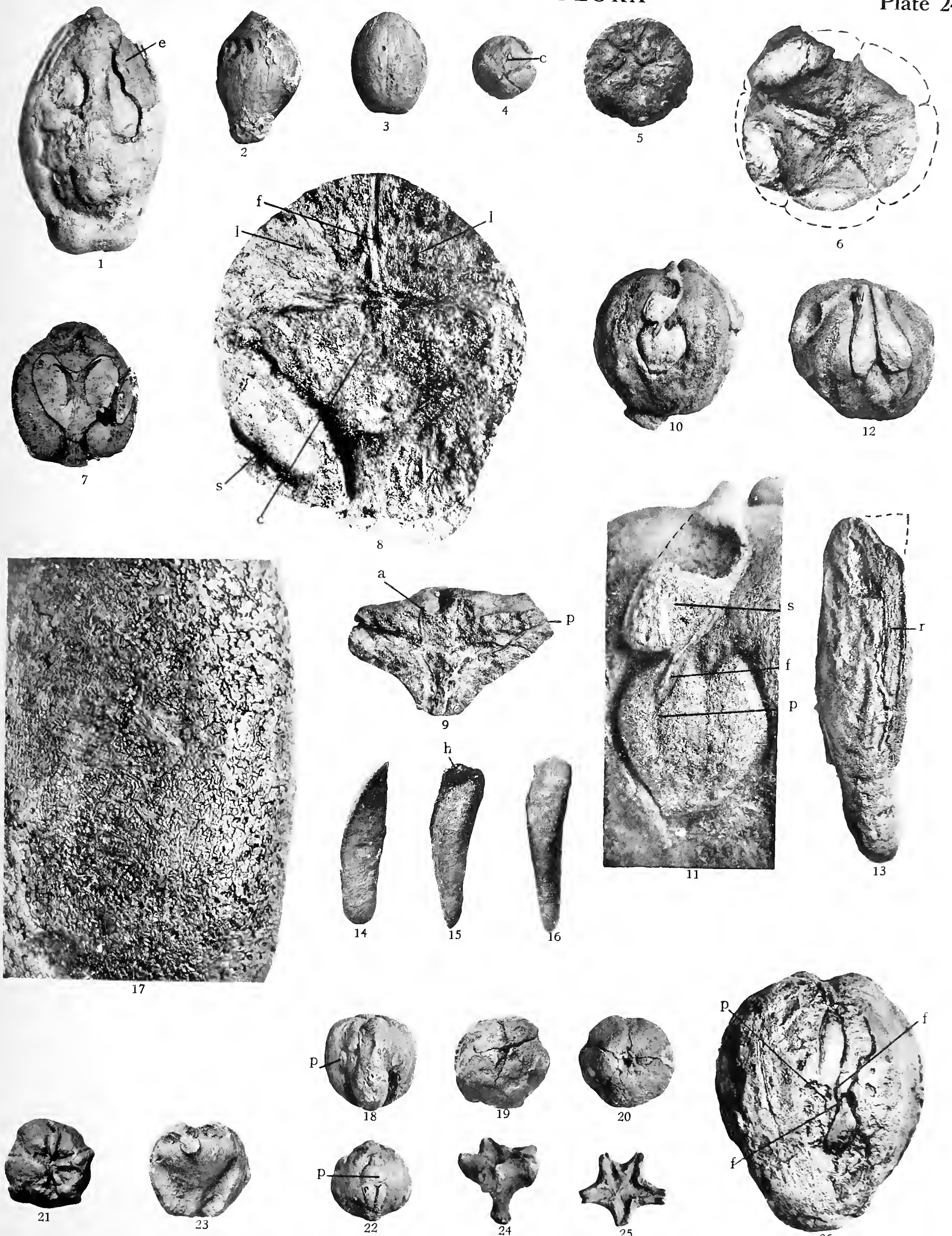

Photo M.E.J.C.

HIGHTEA

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PLATE XXV

Explanation of Plate XXV

FIG.

Mastixia cantiensis n. sp., p. 448.

1.—Endocarp, exterior. × 1·8. V. 22953.

2.—The same, fractured longitudinally (right-hand fragment in fig. 1) showing locule and locule-cast. × 1·8.

3.—A fruit, ventral wall of carpel removed, exposing the convex ventral surface of the locule-cast (cf. right-hand surface of cast in fig. 2). × 1·8. V. 22954.

4.—A transverse section through an endocarp showing the U-shaped section of the locule. The dorsal side faces upwards. × 1·8. V. 22955.

5.—An imperfect locule-cast, ventral, showing on its surface the impression of the raphe. The cast is chipped away at the top, exposing seed and raphe (*r*). × 1·9. V. 22956.

6.—An internal cast of a seed, ventral. The dark longitudinal line is an accidental fracture. × 1·8. V. 22957.

Mastixia grandis n. sp., p. 450.

7.—An endocarp, exterior of dorsal surface. The longitudinal infold of the valve is a deep depression, the loose material which normally fills it having decayed (cf. figs. 4, 14, 15). × 1·9. V. 22968.

8.—The same, lower fragment, viewed from the opposite side. The ventral surface of the locule-cast (*l*) faces the observer; within is the seed (*s*) exposed where the locule-cast is broken. ×1·9.

9.—Endocarp, dorsal valve, inner face; the median infold is much worn, and fissures in the valve are filled with pyrites. × 1·9. V. 22969.

Mastixia parva n. sp., p. 451.

10.—An endocarp. × 2·8. V. 22970.

11.—A fruit with remains of adherent perianth and exocarp. The break at the bottom (left) makes the figure deceptive; the same coat is continuous over the whole surface. The encircling line (*l*) at the apex marks the limit of the accrescent perianth. × 2·6. Herne Bay. V. 22971.

12.—The same, left-hand fragment. Above, in the middle, is the smooth shining seed-cast (*s*, broken below), surrounded by the locule-cast (*l*) and the various carpellary coats in section. The sharp ridges of the endocarp (*e*) are seen in section against the pyritized exocarp and perianth. × 2·6.

13.—An abraded endocarp, dorsal, looking at the exterior of the valve. The soft substance filling the median infold has been replaced by pyrites (white). × 1·8. V. 22972.

14.—A transverse section through a locule-cast (dorsal surface facing upwards). Part of the endocarp is preserved within the infold; but the middle of the infold is filled with pyrites (cf. fig. 13). × 2·8. V. 22973.

15.—An endocarp in transverse section. The infold is partly filled with pyrites. × 2·8. V. 22974.

16.—A locule-cast, side. The dark groove (right) is the depression caused by the dorsal infold. The longitudinal ridge (median in photograph) marks the slight crack between valve and fruit into which mud entered, before the valve and endocarp were worn away. × 1·8. V. 22975.

17.—The internal cast of a seed, ventral, with remains of the endocarp adhering above. × 1·8. V. 22976.

Langtonia bisulcata n. gen. & sp., p. 453.

18.—An endocarp, with one developed, and one abortive locule (facing the camera). The valve of the latter has come partly away exposing the locule above. × 2·8. V. 22984.

19.—The same, lower part, transverse section. The developed locule lies above, and the abortive locule (*a*), delimited by a dark line, below. × 1·8.

20.—A two-loculed endocarp. The valves (*v*) are at the top, right and left. × 2·8. V. 22985.

21.—A locule-cast, ventral face, cemented to the valve on which it lies, the rest of the endocarp having been removed. The thin shell of the cast has been largely chipped away to expose the ventral surface of the seed with its median raphe. × 1·8. V. 22986.

22.—An endocarp in transverse section, showing a developed locule and the curved ventral face (base of figure) of the abortive locule from which valve and locule-cast have fallen. Note the two infolds of the valve and the corresponding form of locule and seed, also the edges of the valve (seen in section as dark streaks passing from the two outer edges of the locule-cast to the margin). × 1·8. V. 22987.

23.—An endocarp in tranverse section with two developed seeds. × 1·8. V. 22988.

24.—A detached valve, exterior. Note the indications of the two infolds. × 1·8. V. 22989.

25.—Another valve, interior, showing the finished margins and the two infolds. × 1·8. V. 22990.

26.—A locule-cast with a film of endocarp adhering, ventral, showing the system of fibres in the endocarp outside the locule-lining. × 1·9. V. 22991.

27.—A locule-cast, dorsal, showing the grooves corresponding to the infolds of the endocarp. Figs. 26 and 27 together show the form of the seed. × 2·8. V. 22992.

Beckettia mastixioides n. gen. & sp., p. 456.

28.—A two-loculed endocarp, exterior, looking on to one of the valves (*v*). × 1·8. V. 23002.

29.—An endocarp, apex, showing the worn valves (lateral prominences). × 1·8. V. 23003.

30.—An endocarp, apex. The valves (right and left) have fallen away, exposing the locule-casts. × 1·8. V. 23004.

31.—A three-loculed endocarp, side; a broken locule-cast and seed are exposed by removal of one valve. × 1·8. V. 23005.

32.—The same, apex. × 1·8.

33.—An endocarp, fractured transversely, showing a developed locule above, and (obscurely) an abortive locule below. × 1·8. V. 23006.

34.—An endocarp with two developed locules, the lower worn. Note the great thickness of the endocarp in the angles between them. × 1·8. V. 23007.

35.—A locule-cast, dorsal, indicating the form of the seed. × 2·8. V. 23008.

36.—The same, ventral. × 1·9.

Lanfrancia subglobosa n. gen. & sp., p. 457.

37.—An abraded four-loculed fruit with the dorsal margins of a locule-cast (U-shaped in transverse section) showing at (*lc*). × 1·8. V. 23014.

38.—The same, apex. The U-shaped locule-cast (*lc*) is obscured by the hard pyritized infilling of the infold, which projects as a ridge. × 1·8.

39.—A three-loculed fruit, apex. One locule-cast is exposed. The two other carpels are separating septicidally (the result of decay). × 1·8. V. 23015.

40.—The same, a detached carpel, ventral; broken near the top, exposing the locule-cast. × 2·8.

Dunstania Ettingshauseni (Gardner) n. gen., p. 459.

41.—A four-loculed endocarp, apex. × 1·6. V. 23022.

42.—Another, apex, with one valve detached. × 1·6. V. 23023.

43.—An endocarp, side, showing the form of the valves (*v*). × 1·6. V. 23024.

44.—V. 23023 (fig. 42) fractured longitudinally to show a locule-cast (right), and (left) the septum with secreting cavities. × 2·8.

45.—The same, a valve with locule-cast adhering (ventral face). × 2·8.

46.—The same valve, inner surface, locule-cast removed. × 2·8.

47.—A seed from the same fruit, dorsal surface, with the raphe (*r*). × 6·6.

Photo M.E.J.C.

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CORNACEAE

PLATE XXVI

Explanation of Plate XXVI

FIG. *Dunstania multilocularis*, n. sp., p. 462.

1.—An endocarp, side, showing a lateral valve, and the apical hollow. × 2. V. 23026.

2.—The same, apex. × 1·9.

3.—A worn endocarp, showing the globular secreting cavities. × 2. V. 23027.

4.—An endocarp, apex, showing a lobed apical hollow. × 1·9. V. 23028.

5.—An endocarp, apex. The large hollow is filled with pyrites. × 1·8. V. 23029.

6.—An endocarp, apex, to show a smaller hollow filled with pyrites. × 1·8. V. 23030.

7.—An endocarp with a valve removed to show one of the seeds. × 2. V. 23034.

8.—A six-loculed endocarp in transverse section. The limits of the valves are shown by the thin intercalations of pyrites (white) along their lateral margins. × 2·7. V. 23031.

9.—A four-loculed endocarp in transverse section, showing the globular secretions. × 2·7. V. 23032.

10.—Part of the same, to show the structure in greater detail. × 6·6.

11.—An endocarp, fractured longitudinally, exposing two locule-casts. × 6·4. V. 23033.

12.—A valve from the endocarp in fig. 7, inner face. × 2·8. V. 23034.

13.—A locule-cast from the same, side; the dorsal surface is on the left. × 2·8.

14.—A seed from the same; the dorsal surface is the light area on the left. × 2·8.

15.—A seed, dorsal, showing the raphe (*r*). × 6·5. V. 23035.

Cornaceae (Section Mastixioideae) Genus ?, p. 459.

16.—A locule-cast covered by a thin film of endocarp. The large dorsal oval hollow, which conforms in shape to the infold of the valve, is now filled with pyrites (*p*). × 2·7. V. 23020.

17.—The same, opposite side. × 2·7.

Leucopogon quadrilocularis n. sp., p. 464.

18.—A perfect fruit, base. × 2·8. V. 23047.

19.—The same, side. × 2·8.

20.—Another specimen (broken on the right) fractured transversely. × 6·5. V. 23048.

FIG. *Ardisia ? eocenica* n. sp., p. 466.

21.—A locule-cast, base, with remains of the much worn endocarp. × 2·8. V. 23052.

22.—The same, in longitudinal section. × 2·8.

23.—The same, side. × 6·5.

Sapoticarpum rotundatum n. gen. & sp., p. 467.

24.—Half a fruit, exterior, showing the laticiferous vessels. × 1·4. V. 23054.

25.—The same, reverse, showing the obscure remains of two locules. × 1·4.

26.—Half a carpel from the same fruit, exterior face on the right, septum on the left. × 1·4.

27.—The same, reverse, showing the locule. × 1·4.

28.—The internal cast of a seed from the same specimen, side. The internal cast of the long hilar scar is turned to the right. × 1·4.

29.—The same seed-cast turned to show the hilar scar. × 1·4.

30.—The same seed-cast, dorsal, to show the sharp dorsal ridge. × 2.

Sapoticarpum latum n. sp., p. 469.

31.—A fruit, exterior. × 1. V. 23056.

32.—The same, fractured, showing the impressions of two fallen seeds (external surface). × 1·5.

33.—The counterpart, showing the impressions of the other sides of the seeds. × 1·5.

34.—A much worn fruit, apex. The carpel wall has almost disappeared, leaving the locule-casts projecting, and within them, in some locules, seed-casts. × 1. V. 23057.

35.—The same, base. × 1.

36.—The same, side. In the middle and right-hand locules the seed-casts are seen. × 1.

37.—The same, a seed-cast, side, detached. The hilum is to the right. To the left are remains of the testa. × 3.

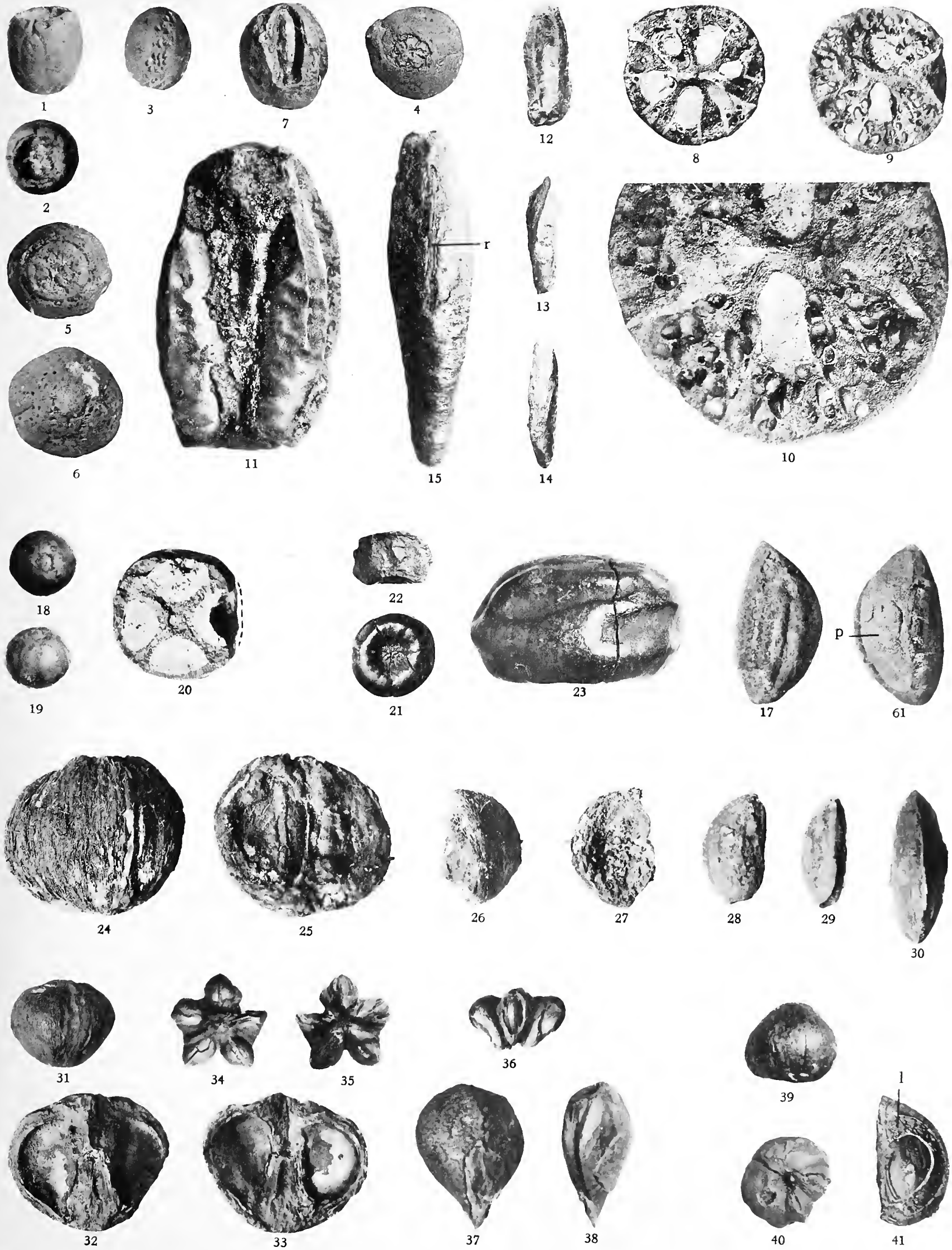
38.—The same, with the cast of the large hilum showing on the left. The fibres branch from the chalaza (broad end). × 3.

Sapoticarpum dubium n. sp., p. 470.

39.—A fruit, exterior. × 1. V. 23059.

40.—The same, base. × 1.

41.—A carpel from the same, showing the locule (*l*) and a fragment of a seed. × 1·5.



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CORNACEAE to SAPOTACEAE

PLATE XXVII

Explanation of Plate XXVII

FIG. *Sapotispermum sheppeyense* n. gen. & sp., p. 471.

1.—Internal cast of a seed with the testa (here very thick) adhering to the ventral margin; the fibres diverge from the chalaza (at the top of the figure). × 2·8. V. 23061.

2.—Internal cast of a second seed. × 3. V. 23062.

Sapotispermum sp. 2, p. 472.

3.—Internal cast of a seed, side. × 3. V. 23067.

4.—The same, looking on to the cast of the hilar scar (dark area to the left). × 3.

Symplocos trilocularis n. sp., p. 473.

5.—A somewhat worn endocarp, side. × 2·8. V. 23068.

6.—The same, apex, showing the openings into the two locules. The abraded opening of the third (abortive) locule is at (*a*). × 2·8.

7.—The same, in oblique longitudinal fracture. The cast of the developed locule is seen in oblique section in the upper part, its surface being exposed below. The abraded opening of the abortive locule is at (*a*). × 2·8.

8.—The counterpart of the above. × 2·8.

9.—The same, transversely fractured. The longitudinal fracture (transverse line in figure) passes through the largest locule. × 2·8.

Symplocos quadrilocularis n. sp., p. 474.

10.—An endocarp, apex. Two of the four apical openings are sectioned across. × 2·8. V. 23069.

11.—The same, showing the fractured face of the lower fragment in fig. 10. The right-hand locule is longitudinally bisected. The left is fractured obliquely so that it only shows near the top. The thin white median longitudinal streak is the central canal of the axis, filled with pyrites. × 2·8.

Symplocos curvata n. sp., p. 475.

12.—A fruit, much worn around the base so that one locule-cast protrudes. × 6·5. V. 23070.

13.—A portion of the fruit fractured to show the seed in place. The thin shell of pyrites (white) surrounding the longitudinally striate testa is the locule-cast. × 6·5.

14.—The same seed isolated, and with most of the testa removed. The micropyle is at the pointed end. × 6·5.

FIG. *Ochrosoidea sheppeyensis* n. gen. & sp., p. 477.

15.—A perfect endocarp, placental margin, with the two valves right and left. × 2·7. V. 23071.

16.—The same, reverse. × 2·7.

17.—The exterior of a valve. × 2. V. 23072.

18.—A two-loculed fruit splitting loculicidally through both locules. × 2. V. 23073.

19.—A similar fruit showing the tendency to break into segments. The valves lie right and left. × 2. V. 23074.

20.—A single carpel; the truncation probably indicates that it belonged to a two-loculed fruit. × 1·7. V. 23075.

21.—A valve, inner face; the locule-cast has been removed. × 2·2. V. 23076.

22.—The counterpart valve, also without the locule-cast. × 2·2.

23.—The locule-cast which lay between these valves. × 2·2.

24.—The upper part of the right-hand valve in fig. 18, showing the upper locule (*l*) in section, partially occupied by pyrites. × 2.

25.—An endocarp, fractured transversely; the two valves are seen above and below. The light rim around the locule-cast is the inner fibrous coat of the endocarp. × 2. V. 23077.

26.—A longitudinal fracture through a locule-cast exposing the surface of a seed-cast. The hilum lies in the concavity below the hooked end of the seed (top left). × 6. V. 23078.

27.—A longitudinal fracture through a locule-cast and seed-cast. The outer coat of the testa is seen in section at (t_1), and the inner coat at (t_2). The outline of the seed is obscured by a gall at (*g*). × 6. V. 23079.

28.—Part of a longitudinal section of an endocarp showing the general transverse arrangement of the cells. × 13. V. 23080.

29.—Part of a transverse section of the same endocarp showing the contorted arrangement of the cells. × 13.

Ochrosella ovalis n. gen. & sp., p. 480.

30.—The valve of an endocarp, interior, with the locule-cast in place. × 6·5. V. 23086.

31.—A transverse section across another endocarp showing the locule-cast lying between the two valves (above and below) and the more rounded seed-cast within (obscure in the figure). × 6·5. V. 23087.

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SAPOTACEAE to APOCYNACEAE

PLATE XXVIII

Explanation of Plate XXVIII

FIG. *Jenkinsella apocynoides* n. gen. & sp., p. 481.

1.—A locule-cast, ventral side; pericarp preserved on the right and along the ventral ridge which is associated with the placenta. The transverse striations are the impressions of fibres lining the locule. × 2·8. Herne Bay. V. 23088.

2.—The same, dorsal. The longitudinal striations are the impressions of fibres in the pericarp. × 2·8.

3.—A locule-cast, ventral, showing the impressions of numerous placentas (?) and of the transverse fibres lining the locule. × 2·7. Herne Bay. V. 23089.

4.—A locule-cast, dorsal. × 2·7. Herne Bay. V. 23090.

5.—A larger locule-cast, broken on the left, ventral, showing the placental region. × 2·7. Herne Bay. V. 23091.

Davisella ehretioides n. gen. & sp., p. 483.

6.—A pyrene, dorsal, showing the ornamentation. × 8. Harefield, Middlesex. V. 23094.

7.—The same, ventral. × 8.

8.—Another pyrene, dorsal. × 8. Harefield. V. 23095.

9.—The same, ventral. At the base, on the left, is one of the arcuate apertures for germination. × 8.

Cantisolanum daturoides n. gen. & sp., p. 484.

10.—A fragment of a fruit with a seed which occupies the whole of the base of the figure; the cells of the testa show best on the left. × 8. V. 23096.

11.—The same, reverse, showing the pericarp in section above, and the oblique alignment of the fibres which line the locule below. × 6.

12.—The crumpled seed removed from the same. The hilum is at (*h*). × 8.

Polycarpella caespitosa n. gen. & sp., p. 486. V. 23097.

13.—Part of a fruiting head. × 2·8.

14.—The same, reverse, showing the axis with attached fruitlets. × 2·8.

15.—Another fragment, inner face. × 2·8.

16.—A flattened fruitlet (base slightly broken). Note the longitudinal strands of fibres. × 6·5.

17.—Another fruitlet, more perfect. × 6·5.

18.—A fruitlet; a fragment of a second, from which a seed (*s*) protrudes, adheres to it on the left. Both show thick strands of fibres. The slight emargination at the top of the fruit is common in the species. × 6·5.

19.—A fruitlet, sectioned longitudinally to show the locule-cast. The accretion on each side of the thick apex (seen in section) is pyrites. × 6·5.

20.—A seed. The surface shown is that which lies parallel to the flat face of a fruitlet. The position of the micropyle is indicated by (*m*) and of the chalaza by (*ch*). × 9·5.

FIG.

21.—A seed showing the face at right angles to the last. The ridge carries the raphe; the micropyle is at (*m*), and the chalaza at (*ch*). × 9·5.

Leyrida bilocularis n. gen. & sp., p. 488.

22.—A fruit with peduncle, side. × 1·85. V. 23099.

23.—Another fruit, without peduncle, side. × 1·85. V. 23100.

24.—A fruit, base, without the peduncle, showing the scar of attachment. × 1·85. V. 23101.

25.—The apex of the fruit in fig. 22. × 1·8.

26.—A fruit, with a valve removed to show a seed-cast in a locule. At the top the large cells of the testa associated with the hilar region (*h*) are preserved. × 6·6. V. 23098.

27.—An endocarp, fractured transversely, showing locules and seed-casts. The raphe lies at the narrow margin of each seed. The infiltration of pyrites (*p*) into the carpel wall along the margins of the valves (*v*), denotes planes of weakness. × 6·6. V. 23102.

28.—A seed, broken on the right margin where the testa is thickened over the hilum (*h*) and raphe. × 6·6. V. 23103.

29.—A seed-cast, showing the margin which carries the raphe and the basi-lateral chalaza (*ch*). × 6·6. V. 23104.

30.—A seed, showing the side turned to the septum. × 6·6. V. 23106.

31.—Another seed, showing the side beneath the valve. × 6·6. V. 23105.

32.—A broken seed, showing the basi-lateral chalaza (*ch*). × 6·6. V. 23107.

Leyrida subglobularis n. sp., p. 489.

33.—An endocarp with a valve removed; it shows a locule-cast. × 2·8. V. 23112.

34.—The same, base, showing two valves detached. × 2·9.

35.—The same, in transverse section, with one developed locule (right, that seen in fig. 33) and two abortive locules (*l*). × 2·9.

36.—A fruit with a valve removed; it shows the seed. × 2·9. V. 23113.

Neuroraphe obovatum n. gen. & sp., p. 491.

37.—A seed with remains of the testa. × 2·6. V. 23115.

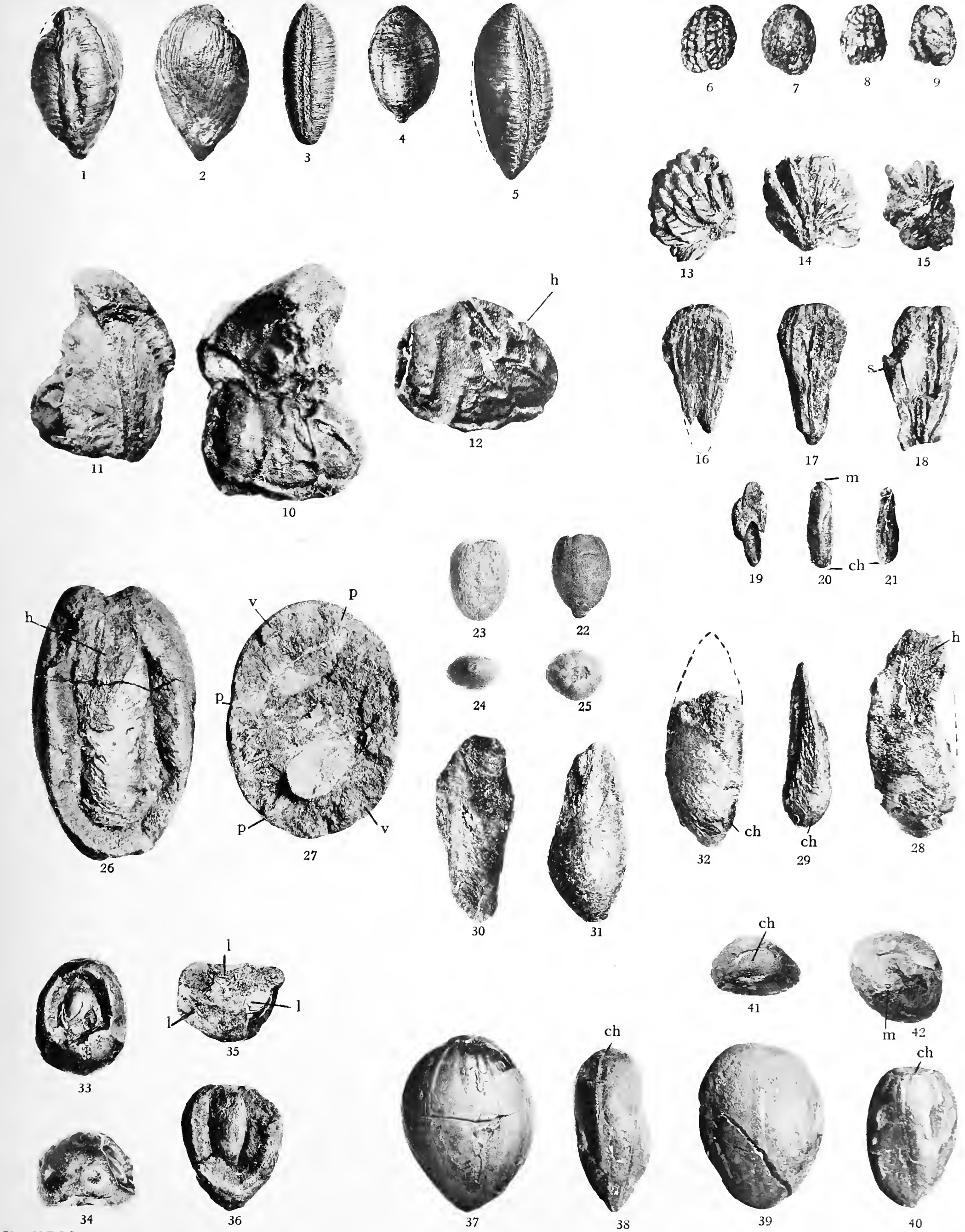
38.—Another seed (distorted), showing the chalaza (*ch*). × 2·7. V. 23116.

39.—Another seed, side. × 2·7. V. 23117.

40.—Another seed, showing the chalaza (*ch*). × 2·7. V. 23118.

41.—The same, the chalaza (*ch*). × 2·8.

42.—Another seed, showing the cast of the micropyle (*m*). × 2·7. V. 23119.



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APOCYNACEAE to INCERTAE SEDIS

PLATE XXIX

Explanation of Plate XXIX

FIG. *Lagenoidea trilocularis* n. gen. & sp., p. 493.

1.—A fruit with a valve removed, looking on to a locule-cast. Thick longitudinal strands of fibres are embedded in the radially directed cells of the exocarp. × 6·5. V. 23126.

2.—A fruit, exterior, side. × 1·5. (Now decayed.)

3.—A four-loculed fruit, apex, showing septicidal and loculicidal splitting. × 1·5. (The specimen is rapidly decaying.) V. 23127.

4.—A larger three-loculed fruit showing splitting as in fig. 6. × 1·5. V. 23128.

5.—Another fruit, with remains of the calyx, base. × 1·5. (Now decayed.)

6.—A worn three-loculed fruit, base, showing the septa and the protruding locule-casts. × 3. V. 23129.

7.—The base of a small, worn, three-loculed fruit. The right-hand locule-cast has fallen. × 3. (Now decayed.)

8.—A valve, interior. It has split from the fruit along the septa, and is beginning to split loculicidally above. Note the radial alignment of the cells, and the longitudinal vascular bundles. × 3. (Now decayed.)

9.—The remains of a calyx and stalk, from below. × 6·5. V. 23130.

10.—Another calyx, from above. × 6·5. V. 23131.

11.—Part of a three-loculed endocarp, looking on to the external edge of one of the septa (*sp*), on each side of which lie locules (*l*) from which the valves and locule-casts have been removed. × 6·8. (Now decayed.)

12.—The same, viewed approximately from behind. On the right is the third locule-cast (*lc*) covered by a thin film of endocarp (cf. fig. 18). × 6·8.

13.—The locule-cast from the left-hand locule in fig. 11. × 6·8. (Now decayed.)

14.—An isolated locule-cast, dorsal, from the fruit in fig. 8. × 7·5. (Now decayed.)

15.—The same, ventral. × 7·5.

16.—A seed-cast (broken at the apex), ventral. The chalaza (*ch*) is at the base. × 8. V. 23132.

17.—A fruit, apex. × 2·2. Brentwood, Essex. V. 23133.

18.—The same, fractured longitudinally, showing a locule-cast with the inner layers of the endocarp covering it (cf. fig. 12), also the radial cells and longitudinal fibres of the exocarp. × 2·2.

FIG. *Lagenoidea bilocularis* n. sp., p. 496.

19.—A fruit with a valve partly removed, showing the upper part of a locule-cast. Note the branching strands of fibres. × 5·7. V. 23141.

20.—The counterpart. × 5·7.

21.—A fruit, broader above than below, showing the thick septum and the valves right and left. × 5·7. V. 23142.

22.—Another fruit, broader below than above, in the same position as the last. × 1·2. V. 23143.

23.—A fruit, base, showing the lateral compression. × 1·2. V. 23144.

24.—A fruit, basi-lateral view, showing septa and valves. × 1·2. V. 23145.

25.—A fruit with a valve removed showing a locule-cast. × 2·8. V. 23146.

26.—A fruit in transverse section; the locule-casts (*l*) are partly obscured by decaying carbonaceous matter. The valves lie right and left, and between them is the thick septum. × 2·8. V. 23147.

27.—A longitudinal tangential fracture of a fruit at right angles to the septum, cutting dorsi-ventrally into both locules. It shows the seed (*s*) in the left locule, and the radial arrangement of the cells of the pericarp. × 6·6. V. 23148.

Lagenella alata n. gen. & sp., p. 497.

28.—A fruit, side. The locules lie with their longer transverse axes at right angles to this face. × 2. V. 23156.

29.—The same, the side at right angles to that shown in fig. 28. × 2.

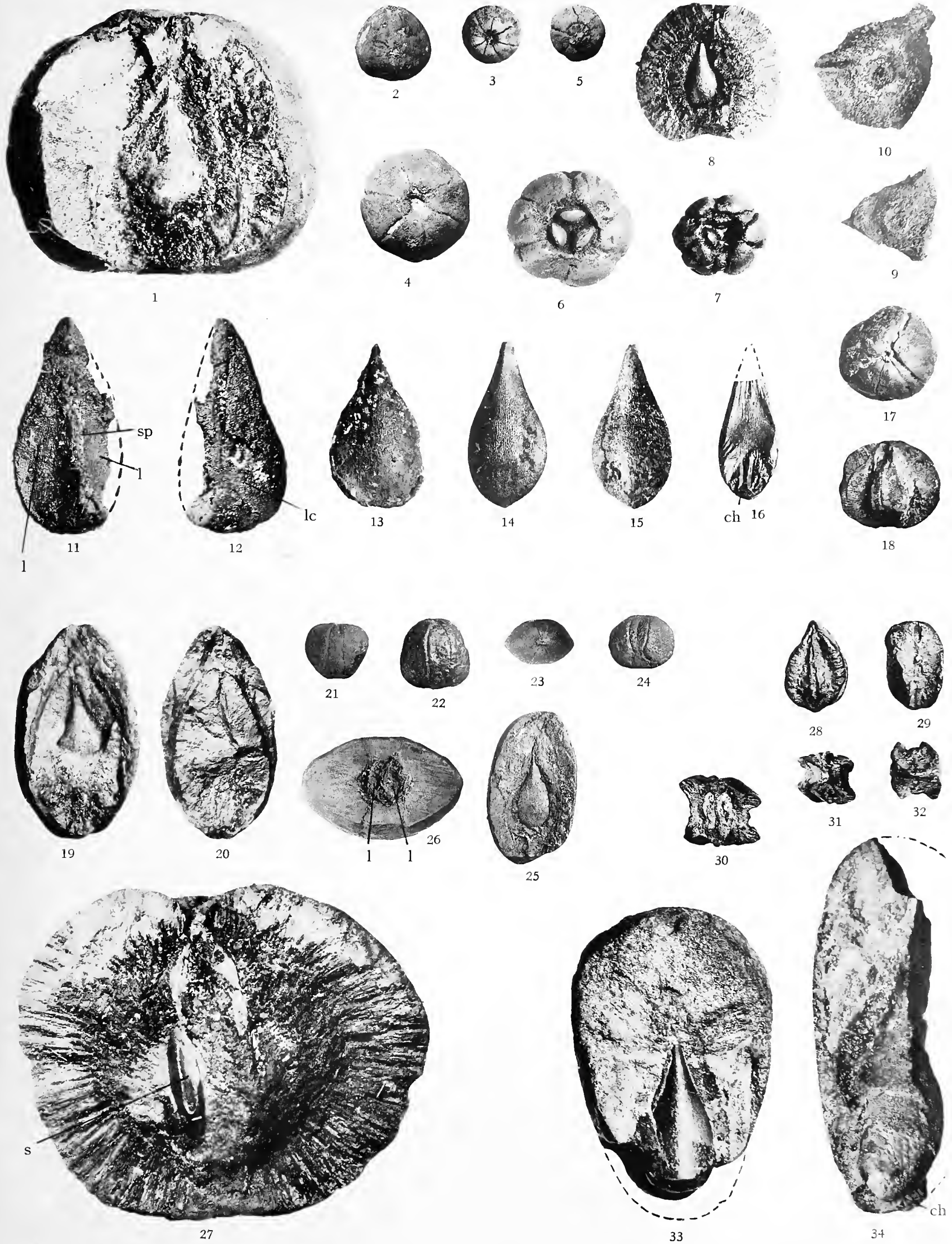
30.—The same, in transverse section. The faces corresponding with that in fig. 28 lie top and bottom. Those corresponding with that in fig. 29 lie right and left. × 2·8.

31.—The same, base, oriented as in fig. 30. The upper and lower faces, seen in profile, correspond with the one seen in fig. 28. × 2.

32.—The same, apex. The upper and lower faces correspond with the one shown in fig. 29. × 2.

33.—An endocarp. At the base the two locule-casts (one in shadow) protrude through the worn pericarp. By removal of a valve the upper part of one cast has been exposed. × 6·6. V. 23157.

34.—A fruit, fractured to expose the seed-cast, on which is the impression of the chalaza (*ch*). × 6·5. V. 23158.



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LAGENOIDEA, LAGENELLA

PLATE XXX

Explanation of Plate XXX

FIG. *Carpolithus subfusiformis* (Bowerbank), p. 499.

1.—Internal cast of a four-partite fruit with some of the pericarp adhering, side. × 1·4. V. 23162.

2.—The same, base. A cord of fibres lies in each ridge. × 1·4.

3.—The same, apex; the hole is accidental. × 1·4.

4.—A three-partite cast, apex. × 1·4. V. 23163.

5.—The same, side. × 1·4.

Carpolithus monasteriensis n. sp., p. 504.

6.—A worn endocarp, exterior. × 2·8. V. 23164.

7.—The same, base. The bases of four locule-casts are protruding; the fifth and sixth are shown by (*l*). × 2·8.

8.—The same, in oblique longitudinal section, showing two locules. × 2·8.

Carpolithus thunbergioides n. sp., p. 505.

9.—A worn fruit which has dehisced loculicidally showing the locule-cast (exposed through abrasion). × 2·8. V. 23165.

10.—The upper fragment of the left valve in fig. 9, with the locule-cast. × 6·5.

11.—The right valve in fig. 9, showing the impression of the locule-cast. × 6·5.

12.—An isolated locule-cast to show the sculpture; where chipped away the seed-cast (*s*) is seen. × 2·8. Herne Bay. V. 23166.

13.—Another locule-cast. × 2·8. V. 23167.

Carpolithus lignosus n. sp., p. 506.

14.—A worn five-loculed fruit, partly broken into cocci (fitted together for photography), side. The thick ribs are the septa; the narrow ones, the protruding radially arranged locule-casts (*l*). The carpels are truncate above. × 1·8. V. 23168.

15.—The same, base, showing the locule-casts (*l*) protruding. × 1·9.

16.—A coccus, side. Note the apical truncation. × 2·8. V. 23168*a*.

17.—A seed, side. × 2·8. V. 23168*b*.

Carpolithus ebenaceoides n. sp., p. 508.

18.—A seed, side, showing the raphe (*r*). × 2·8. V. 23169.

Carpolithus quadripartitus n. sp., p. 509.

19.—Fruit, side. × 2·8. V. 23170.

20.—A half-coccus from the same, with the locule-cast exposed. The primary plane of dehiscence is on the right, and the secondary plane on the left. × 2·8.

21.—The counterpart half; primary plane of dehiscence on the left. × 2·8.

FIG. *Carpolithus bignoniformis* n. sp., p. 510.

22.—Locule-cast of a large pod? × 0·63. In the Royal Museum, Canterbury.

23.—The same, reverse. Note the curved impressions right and left, which may be those of winged seeds. × 0·63.

Carpolithus ranunculoides n. sp., p. 511.

24.—A fruit, embedded in sandy limestone, seen in irregular longitudinal fracture along the plane of symmetry, inner surface. The stone has split along the crack, the two portions meeting at an acute angle so that half the specimen (grey) is on one fragment and half (black) on the other. The style is at (*st*), the ventral margin at (*vm*), the attachment at (*a*). The endocarp (*end*) has broken irregularly. × 2·7. Assington, Suffolk. V. 23171.

25.—Part of the counterpart. Lettering as in fig. 24. The locule-cast (*l*) bears impressions of the lining-layer of the endocarp. The seed-cast is exposed at (*s*). × 2·7.

Carpolithus semencorrugatus n. sp., p. 513.

26.—A fruit, side. × 2·8. V. 23172.

27.—The same, ventral, with the carpel partly removed from this face. × 2·8.

28.—The same, side, with more of the carpel removed. × 2·7.

29.—The seed from the same, dorsal, after removal of the carpel and the locule-cast. × 2·75.

30.—The same, ventral. × 2·6.

31.—The same, side. × 2·7.

32.—The same, base. × 2·8.

Carpolithus olacaceoides n. sp., p. 514.

33.—An endocarp. × 1·3. V. 23174.

Carpolithus Stonei n. sp., p. 515.

34.—An endocarp (broken below) which seems to have dehisced by five valves. A valve with a median rib occupies the centre of the figure. × 1·4. Watford Heath. V. 6467.

35.—The same, with one valve (that on the left in fig. 34) removed, looking into the central cavity. × 1·4.

36.—The same, apex, with all the valves in position. × 1·3.

37.—The detached valve, inner face. × 1·4.

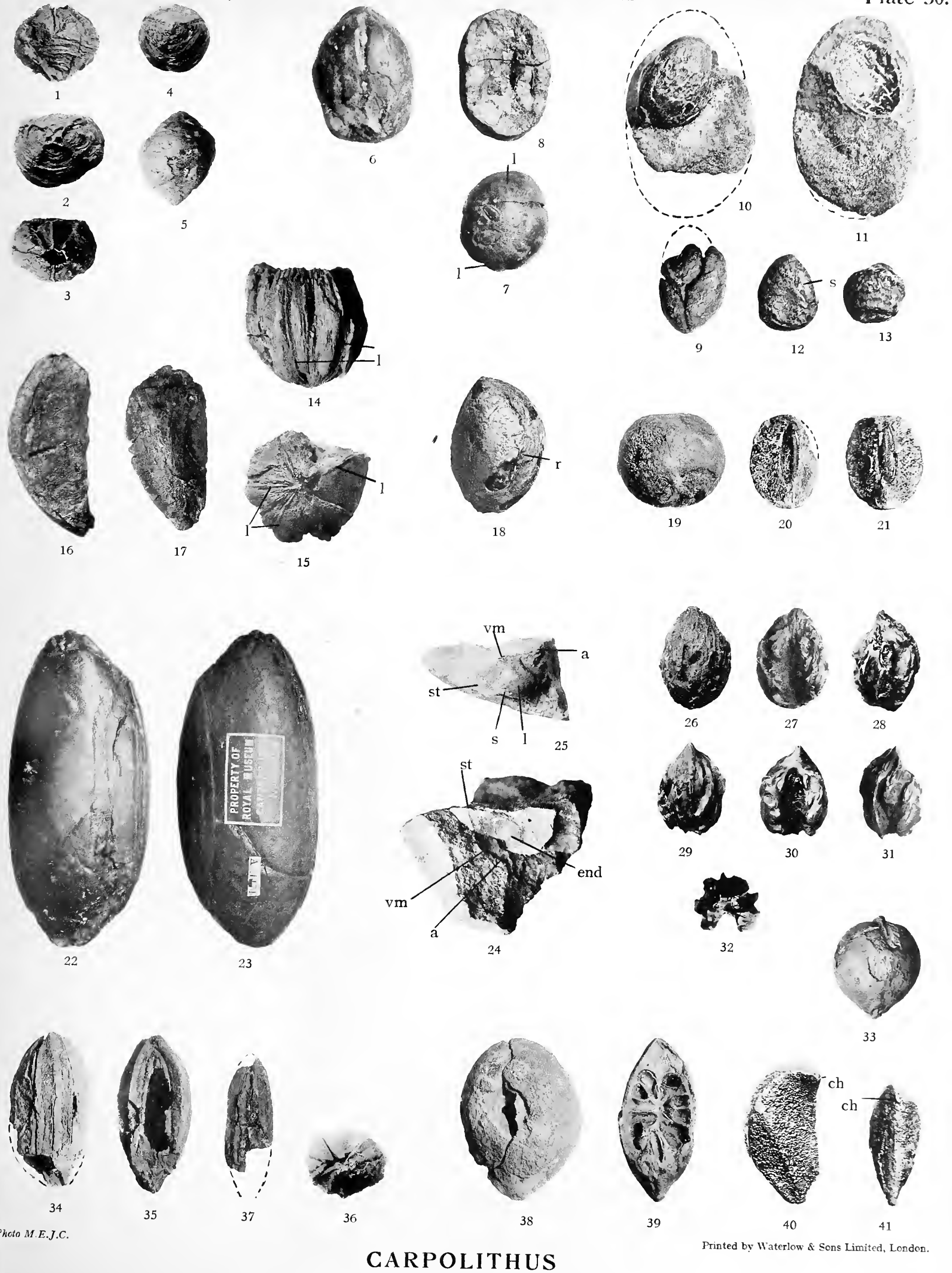
Carpolithus Bowerbanki n. sp., p. 515.

38.—A fruit, exterior. × 1·4. V. 23175.

39.—The right-hand fragment in fig. 38, interior, showing the seeds. × 1·4.

40.—A seed with the testa, side. The chalaza is at (*ch*). × 6.

41.—A seed, ventral, with most of the testa removed. The lower part shows the cells of the tegmen. The chalaza is at (*ch*). × 6.



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CARPOLITHUS

PLATE XXXI

Explanation of Plate XXXI

FIG. *Carpolithus nervosus* n. sp., p. 517.

1.—A fruit, with the pericarp partly removed so as to show the seed. × 2·1. V. 23176.

2.—The same, looking on to one end (probably the apex). × 1·3.

3.—The same, the other end. × 1·3.

4.—A fruit, with the pericarp removed below. × 1·6. V. 23177.

5.—A fruit, with most of the carpel removed. The impression of the transverse fibres lining the locule is seen above on the locule-cast; the seed is exposed below, and on the right at (*s*), where the locule-cast, seen in section at (*l*), is broken. × 1·6. V. 23178.

6.—The base of the specimen in fig. 5. × 1.

Carpolithus scalariformis n. sp., p. 518.

7.—Part of a broken valve, exterior. × 2·7. V. 23182.

8.—The same, interior, showing the seed-pockets, and (right side) the oblique ridges connected with them. × 2·7.

9.—A broken valve, interior, showing seed-pockets and seeds. × 2·7. V. 23183.

10.—A broken valve, interior. × 2·7. V. 23184.

11.—A section across the valve in fig. 10, showing the large cells of the thick carpel wall, and the seed pockets in transverse section. × 5·7.

12–14.—Seeds, viewed at right angles to those shown in figs. 9, 10, which are seen edgeways. × 8·7. V. 23185.

Carpolithus sp. 20, p. 520.

15.—The valve of a fruit, inner face. × 1·4. V. 23187.

Carpolithus sp. 21, p. 520.

16.—A fruit, exterior. × 2. V. 23188.

17.—The same, fractured longitudinally, showing an abortive, erect seed. × 2.

18.—The counterpart of the specimen in fig. 17. × 2.

Carpolithus sp. 22, p. 520.

19.—An endocarp dehiscing by two valves (right and left), end view. × 2. V. 23189.

Carpolithus sp. 23, p. 521.

20.—An abraded two-valved fruit. The median scar may mark the placenta. × 1·5. V. 23190.

21.—The same, in transverse fracture. The face shown in fig. 20 turned downwards. Note the thickness of the pyritized carpel wall (left side), and the distorted seed (black). × 1·4.

Carpolithus sp. 24, p. 521.

22.—A one-loculed endocarp fractured so as to show the seed. Note the large cells of the testa (seen at the top of the seed). × 6·7. V. 23191.

FIG. *Carpolithus* sp. 25, p. 522.

23.—A worn fruit, side. × 2. V. 23193.

24.—The same, fractured longitudinally, showing the cast of one of the five locules. × 2.

Carpolithus sp. 26, p. 522.

25.—A one-loculed fruit, exterior. × 6·5. V. 23194.

26.—The same, fractured longitudinally, showing the locule-cast. × 6·5.

27.—The locule-cast of the same, isolated. × 6·5.

Carpolithus sp. 27, p. 523.

28.—A locule-cast, side. The longitudinal groove marks the plane of symmetry between the seeds. × 2·8. V. 23195.

29.—The same, end, with the groove at the top. The crack follows the plane of symmetry. × 2·8.

Carpolithus sp. 28, p. 523.

30.—A locule-cast (or seed-cast ?), ventral. × 2·8. V. 23196.

31.—The same, dorsal. Note the slender median furrow. × 2·8.

32.—The same, side. × 2·8.

Carpolithus sp. 29, p. 524.

33.—A four-partite fruit, one end. In the grooves are strands of fibres. × 2·8. V. 23197.

34.—The same, the opposite end. × 2·8.

Carpolithus sp. 30, p. 524.

35.—A berry, side. × 1·8. V. 23198.

Carpolithus sp. 31, p. 525.

36.—An endocarp, apex, showing dehiscence into two valves. × 1·8. V. 23199.

37.—The same, side. × 1·8.

Carpolithus sp. 32, p. 525.

38.—An endocarp, side. × 6. V. 23200.

39.—The same, reverse side. × 2·8.

Carpolithus sp. 33, p. 526.

40.—A three-lobed internal cast of a fruit. × 2·9. V. 23201.

Carpolithus sp. 34, p. 526.

41.—A two-valved endocarp; one valve is broken. × 1·6. V. 23202.

42.—The broken valve, interior; with locule-cast showing funicle (*f*), placenta (*p*), and stylar canal (*st*). × 3.

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CARPOLITHUS

PLATE XXXII

Explanation of Plate XXXII

FIG.

Carpolithus sp. 35, p. 527.

1.—Counterpart specimens placed together showing the external impressions of a fruit. × 2·7. Assington, Suffolk. V. 23203.

Carpolithus sp. 36, p. 527.

2.—Internal cast of a five-partite, one-loculed fruit. × 2. V. 23204.

Carpolithus sp. 37, p. 528.

3.—A pentagonal locule-cast. × 1·2. V. 23205.

Carpolithus sp. 38, p. 528.

4.—A much worn endocarp, side. × 2·8. V. 23206.

5.—The same, apex. × 2·7.

6.—The same, at right angles to the side seen in fig. 4. × 2·8.

7.—The same, base. × 2·7.

8.—A smaller specimen with some of the exocarp preserved. × 2·9. V. 23207.

9.—The same, sectioned along the groove seen in fig. 8, showing an erect abortive seed (*s*), also the thick spongy (?) endocarp and the hard exocarp (right side below). × 5·7.

Carpolithus sp. 39, p. 529.

10.—A trigonous seed or nut, broken on the right side. × 1·2. V. 23211.

Carpolithus sp. 40, p. 529.

11.—A six-lobed locule-cast. × 1·27. V. 23212.

Carpolithus sp. 41, p. 530.

12.—A locule-cast, broken on the left, showing the seed within. × 2·8. V. 23213.

13.—The seed from the same. × 5·7.

Carpolithus sp. 42, p. 530.

14.—An endocarp, side. × 2·8. V. 23214.

15.—The same, margin. × 2·8.

Carpolithus sp. 43, p. 531.

16.—An inflorescence (?), exterior. × 2·8. V. 23216.

17.—The same, fractured transversely. × 6·5.

Carpolithus sp. 44, p. 531.

18.—A valve belonging to a two-valved fruit, interior, showing the impression of a seed on the locule-cast. The median raised area is accidental, due to shrinkage of the seed, and has no structural significance. × 1·5. V. 23217.

FIG.

Carpolithus sp. 45, p. 532.

19.—A syncarpous, ten-loculed fruit, with the locule-casts protruding through the much worn pericarp. × 1·9. V. 23218.

Carpolithus sp. 46, p. 532.

20.—A much worn endocarp, side. × 1·3. V. 23219.

21.—The same, margin. × 1·3.

Carpolithus sp. 47, p. 533.

22.—A locule-cast with a fragment of the endocarp covered by pyrites. × 2·8. V. 23221.

23.—The same, reverse, worn so as to expose the raphe (*r*) and the testa (*t*). × 2·8.

24.—The same, end. × 2·5.

Carpolithus sp. 48, p. 534.

25.—A locule-cast, dorsal, showing remains of the pericarp. × 2·9. V. 23222.

26.—The same, ventral. Note the large median aperture, perhaps representing the cast of the funicle. × 2·9.

27.—The same, side, dorsal surface on the left. × 2·9.

Carpolithus sp. 49, p. 534.

28.—A locule-cast, side. × 2·8. V. 23223.

29.—The same, apex. × 2·8.

30.—A locule-cast, apex. Where the cast is chipped away, above, the seed (*s*) is seen with longitudinal strands of fibres (very obscure in the figure). × 2·8. V. 23224.

31.—A locule-cast, base, showing the five-angled form. × 2·8. V. 23225.

Carpolithus sp. 50, p. 535.

32.—An endocarp, or seed, showing the area of attachment (?). × 6·5. V. 23228.

33.—The same, side. × 6·5.

Carpolithus sp. 51, p. 535.

34.—A locule-cast with remains of the pericarp, side. × 2·8. V. 23229.

35.—The same, in longitudinal section. The pericarp is thickened at the concave end. × 2·8.

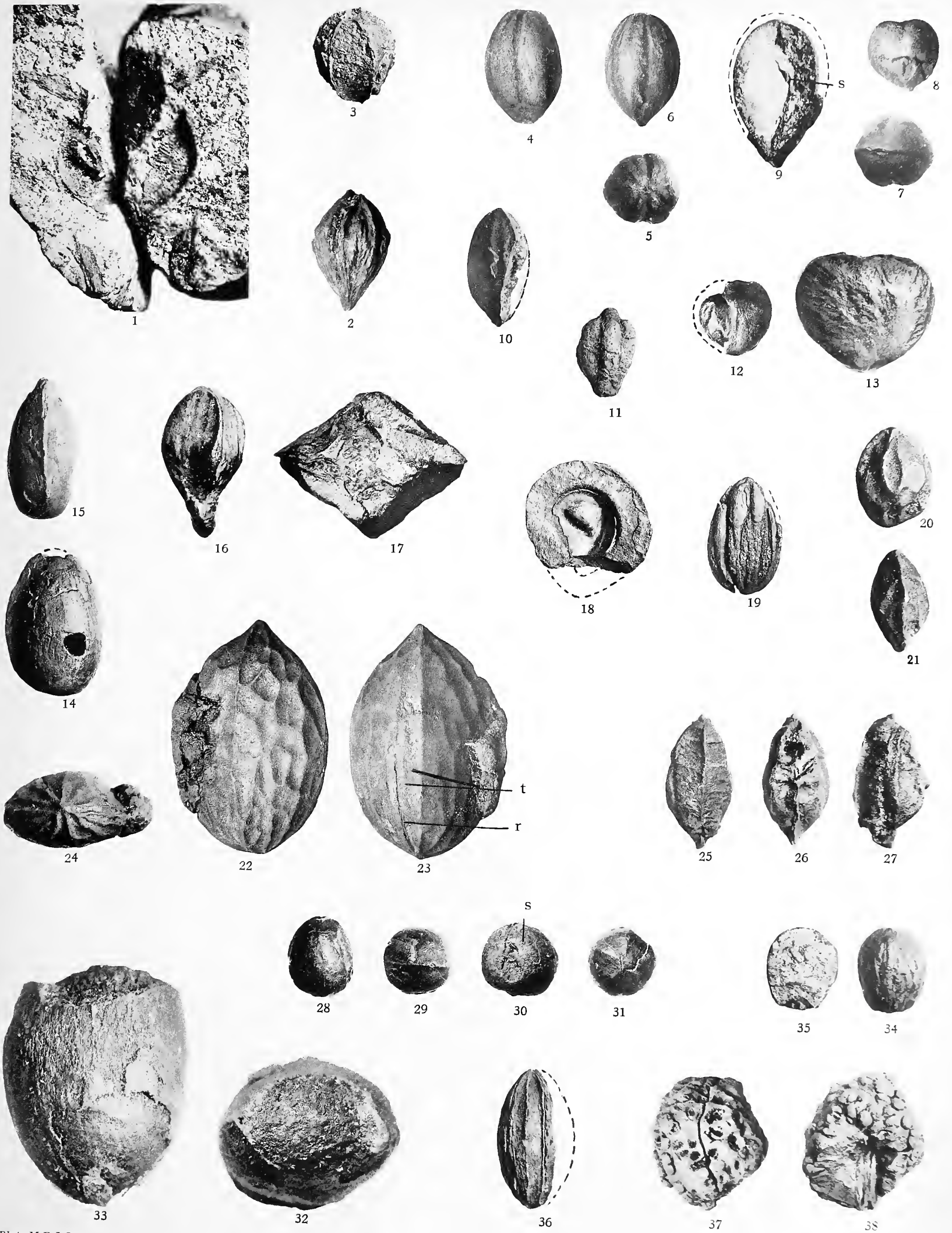
Carpolithus sp. 52, p. 535.

36.—A ribbed locule-cast (? eight ribs), imperfect on the right. × 1·7. V. 23230.

Receptacle ?, p. 537.

37.—A receptacle (?), exterior. × 2. V. 23231.

38.—The same, reverse, broken, and showing the axis. × 2.



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CARPOLITHUS

PLATE XXXIII

Explanation of Plate XXXIII

FIG. Bored wood, Tubers, Burrs, or Galls, p. 537.

1.—A piece of bored wood, exterior, to show the opening. × 1·25. V. 23233.

2.—The same, with the opening at the top of the figure. × 1·25.

3.—Another specimen, exterior. × 1·1. V. 23257.

4.—The same, fractured to show the wide fusiform cavity filled with pyrites, and the radiating, coarse, cell-structure. × 1·2.

5.—Another specimen, exterior. × 1·1. V. 23234.

6.—The same, after longitudinal fracture, to show the narrow cavity (now filled with pyrites). Note the fine grain of the wood and the medullary rays, seen as faint transverse striae. The bore does not penetrate the upper end. × 1·2.

7.—A similar specimen, fractured longitudinally to show the narrow bore and single opening. × 1·2. V. 23235.

8.—Another specimen. × 1·2. V. 23236.

9.—A piece of wood, fractured to show a globular cavity (now filled with pyrites) having two openings. Similar to *Xulinosprionites latus* Bowerbank, but with only one chamber. × 1·2. V. 23240.

10.—A typical example of *Xulinosprionites zingiberiformis* Bowerbank. The lower chamber is fractured to show the woody structure, and the cavity in section. × 1·1. V. 23241.

11.—The exterior of another two-chambered specimen, showing surface pittings. × 1·1. V. 23242.

12.—A specimen, similar to *Xulinosprionites latus* Bowerbank, with two chambers, exterior. × 1·2. V. 23243.

13.—The same, fractured to show the cavities filled with pyrites. × 1·2.

14.—A spindle-shaped specimen, exterior, simulating a fruit. × 2·5. V. 23249.

15.—The same, fractured to show the cavity now filled with pyrites. × 2·5.

16.—A similar specimen. × 1·3. V. 23248.

17.—Another specimen, simulating a fruit, broken at one end. × 1·3. V. 23250.

FIG.

18.—Transverse section of the same showing the cavity filled with pyrites. × 1·9.

19.—A woody nodule, exterior, probably a gall, with central cavity having two exits. × 1·1. V. 23261.

20.—The same, fractured to show the cavity and the exits (*e*). × 1·1.

21.—Another woody nodule, possibly a gall, with a globular cavity having one exit. × 1·3. V. 23262.

22.—Another woody nodule with curved cavity. × 1·2. V. 23265.

23.—A woody nodule with a cavity, showing the impression of the upper surface of a small insect pupa. × 2·6. In. 31396.

24.—The counterpart of the upper part of fig. 23, showing the impression of the lower surface of the pupa. × 2·6.

25.—The pupa removed from the same, upper surface. × 2·6.

26.—A mass of angular parenchyma, possibly a gall, exterior. The scars may mark exits. Alternatively, the specimen may be a tuber, the scars marking buds. × 1·25. V. 23266.

27.—Another smaller specimen. × 2·5. V. 23267.

28.—The same, fractured to show the structure. × 2·5.

Concretions, p. 541.

29.—A concretion simulating a leguminous seed, side. × 1. V. 23270.

30.—The same, margin (right hand in fig. 29). × 1.

31.—The same, opposite margin (left hand in fig. 29). × 1.

32.—A concretion simulating a nut in a cupule. × 1·8. V. 23271.

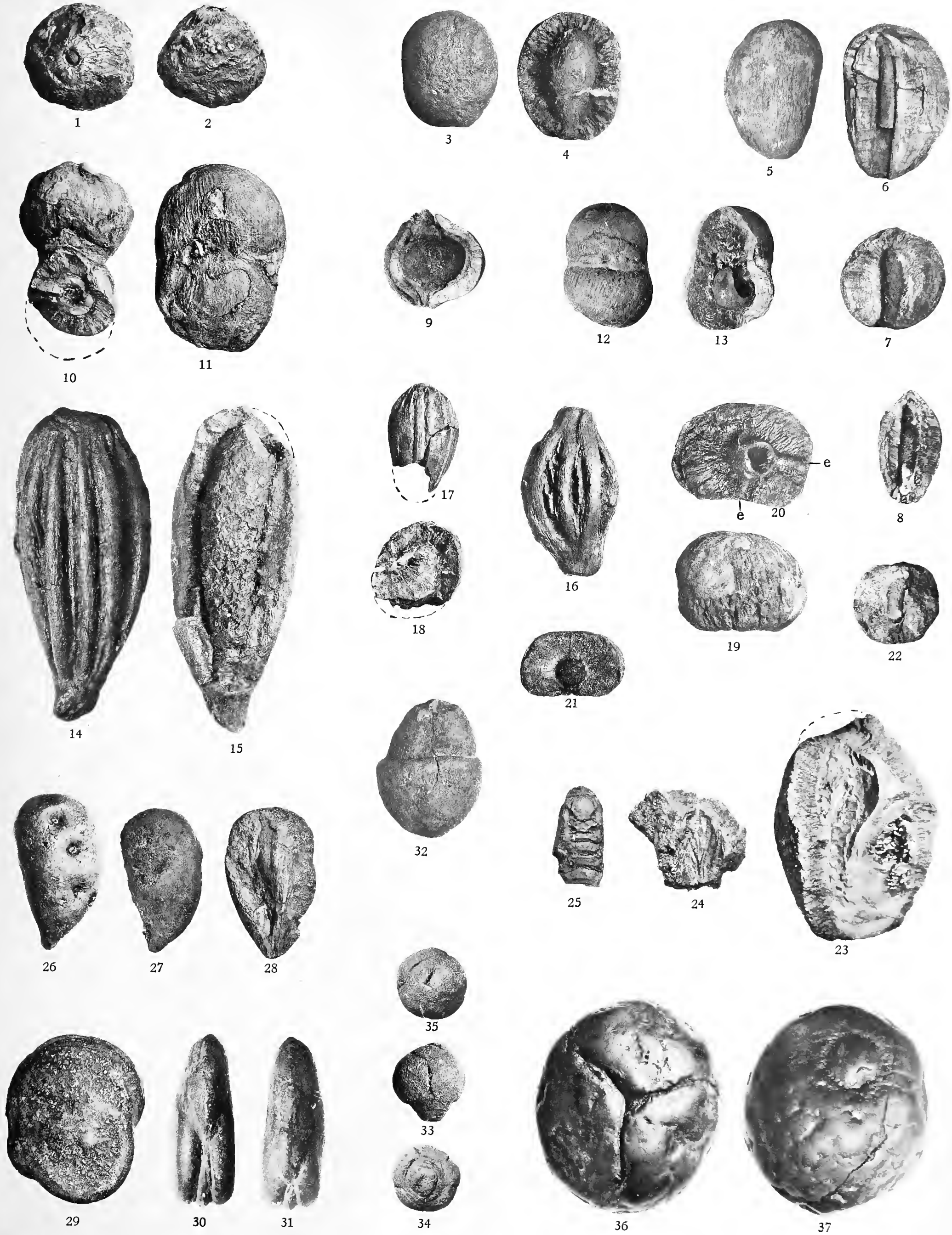
33.—A concretion described by Bowerbank as *Cupressinites tesselatus*. × 1·5. V. 23272.

34.—The same, the base in fig. 33. × 1·5.

35.—The same, the apex in fig. 33. × 1·5.

36.—A concretion simulating a palm-seed. × 1·9. V. 23273.

37.—The same, reverse, with a circular area simulating an embryo-scar. × 1·9.



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BURRS, GALLS, CONCRETIONS

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